1994 ACE PLAN

Aviation Capacity Enhancement

DOT/FAA/ASC-94-1

U.S. Department
of Transportation

**Federal Aviation
Administration**

Prepared by:
Federal Aviation Administration
Office of System Capacity
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Washington, DC 20591

U.S. Department
of Transportation

**Federal Aviation
Administration**

Office of the Administrator

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I am pleased to present the *1994 Aviation Capacity Enhancement Plan*. Building system capacity that will minimize delays and allow fair access for all types of aviation is one of seven key strategic issue areas for the Federal Aviation Administration (FAA).

Aircraft delays cost the airlines and their passengers millions of dollars each year. Over the last 3 years, the same 23 airports have experienced 20,000 hours or more of annual aircraft flight delays, even though the demand for aviation services has been relatively static and the number of flights delayed 15 minutes or more has declined systemwide. The latest aviation activity forecasts (March 1994) project a moderate rate of growth in passenger enplanements and air carrier aircraft operations as the United States economic recovery gathers strength. As the number of aircraft operations increases, the level of delay will increase unless improvements are made to aviation system capacity.

The FAA is committed to increasing the capacity and reducing delays in the National Airspace System. In an effort to energize and refocus our efforts, I recently announced the creation of the Administrator's Council on Capacity. The Council will be chaired by the Assistant Administrator for Airports and the Executive Director for System Operations. The Council, working closely with industry, will be responsible for developing priorities for agency programs based on their impact on capacity and will provide impetus to accelerate the development of near term capacity initiatives.

Improving aviation system capacity is a continuing dynamic process that evolves as user needs change and technology advances. This plan attempts to identify and facilitate actions that can be taken by both the public and private sectors to prevent projected growth in delays while at the same time remain flexible and practical in order to accommodate future change.

This plan supports the FAA Strategic Plan, which is consistent with the Secretary of Transportation's National Transportation Policy.

David R. Hinson
Administrator

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16. Abstract

A comprehensive review of Federal Aviation Administration programs intended to improve the capacity of the National Air Transportation System. The Plan identifies the causes and extent of capacity and delay problems currently associated with air travel in the U.S. and outlines various planned and ongoing FAA projects with the potential to reduce the severity of the problems in the future. The major areas of discussion are:

1) Airport Development
2) Airport Capacity
3) Airspace Capacity
4) New Instrumant Approach Procedures
5) Technology for Capacity Improvement
6) Marketplace Solutions

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Introduction

1.1 The Need for Aviation System Capacity Improvement

In 1993, 23 airports each exceeded 20,000 hours of annual flight delays. With an average aircraft operating cost of about $1,600 per hour of delay,[1] this means that each of these 23 airports incurred at least $32 million dollars in annual delay costs. By 2003, the number of airports that will exceed 20,000 hours of annual delay is projected to grow from 23 to 32, unless capacity improvements are made.[2] The purpose of this plan is to identify and facilitate actions that can be taken to prevent the projected growth in delays. These actions include:

- Airport Development.
- New Air Traffic Control Procedures.
- Airspace Development.
- New Technology.
- Marketplace Solutions.

In 1993, 23 airports exceeded 20,000 hours of annual flight delays. By 2003, the number of airports that will exceed 20,000 hours of annual delay is projected to grow to 32, unless capacity improvements are made.

For three consecutive years, the number of flights exceeding 15 minutes of delay has declined. After a decrease of just over 24 percent from 1990 to 1991, flights exceeding 15 minutes of delay decreased nearly 6 percent in 1992 compared to 1991 and nearly 2 percent in 1993 compared to 1992. The forecast for 32 airports exceeding 20,000 hours of annual delay in 2003 is eight less than the 40 airports predicted three years ago for the year 2000. These and other delay statistics reflect three years of declining or almost static aviation activity.

In the United States, economic growth has averaged only 1.9 percent annually during the 1990s, a period that included a three-quarter economic recession in 1990 and 1991. The slow pace of the economic recovery in this country and economic re-

1. The actual average aircraft operating cost is $1,587 per hour. The cost for heavy aircraft 300,000 lbs. or more is $4,575 per hour of delay, large aircraft under 300,000 lbs. and small jets, $1,607 per hour, and single-engine and twin-engine aircraft under 12,500 lbs., $42 and $124 per hour respectively. These figures are based on 1987 dollars, the latest data available.
2. For a listing of airports exceeding 20,000 hours of annual delay, see Table 1-4 and Figure 1-5.

cessions in several major world trade areas have had a significant impact on the demand for aviation services. Commercial air carrier domestic passenger enplanements have increased at an annual rate of only 0.8 percent during the last four years.

Even with overall demand for air travel relatively static, demand at the most congested airports remained high. The same 23 airports have experienced over 20,000 hours of annual aircraft flight delays since 1990.

Yet, even with overall demand for air travel relatively static, demand at the most congested airports remained high. The same 23 airports have experienced over 20,000 hours of annual aircraft flight delays since 1990. As the economy continues to recover, the demand for air travel will grow. As the number of aircraft operations increases to meet that demand, the level of delay will increase concurrently unless improvements are made to system capacity.

Over the next twelve years, the economy is expected to rebound and sustain a moderate rate of growth averaging 2.6 percent.[3] Gross domestic product (GDP) is a significant indicator of business activity, which, in turn, drives aviation activity. Figure 1-1 illustrates the historical growth in GDP and commercial air carrier domestic passenger enplanements since 1965 and the anticipated growth through 2005.

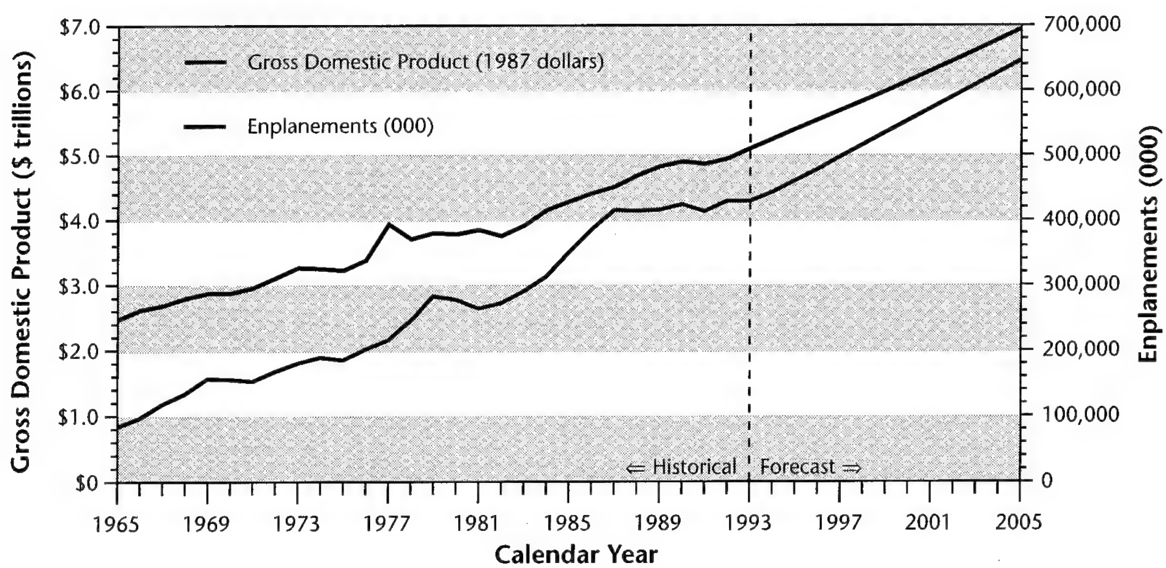

Figure 1-1. Growth in Gross Domestic Product and Domestic Passenger Enplanements, 1965 to 2005

According to FAA aviation forecasts,[3] air carrier domestic passenger enplanements are expected to increase at an average annual rate of 3.5 percent between 1994 and 2005, and domestic air carrier aircraft operations are forecast to increase at an average annual rate of 1.9 percent during the same twelve-year period. The higher growth predicted for passenger enplanements relative to aircraft activity is the result of significantly higher load factors, larger seating capacity for air carrier aircraft, and longer passenger trip lengths. International air carrier passenger enplanements are forecast to increase at an annual rate of 6.5 percent, and regional/commuter airline passenger enplanements are expected to grow 6.9 percent annually.

According to FAA aviation forecasts, air carrier domestic passenger enplanements are expected to increase at an average annual rate of 3.5 percent between 1994 and 2005, and domestic air carrier aircraft operations are forecast to increase at an average annual rate of 1.9 percent.

Although the current delay forecasts continue to project serious delays in the absence of capacity improvements, the message contained in succeeding chapters is positive. For example, a great deal is being done to improve capacity and reduce delays through new construction projects at airports and recent enhancements in Air Traffic Control (ATC) procedures. Airspace capacity design projects are being undertaken to study the terminal airspace associated with delay-impacted airports across the country. In addition, there are many emerging technologies in the areas of surveillance, communications, and navigation that will further improve the efficiency of new and existing runways and of terminal and en route airspace.

In fact, these capacity-producing improvements are frequently interrelated; changes in one often require changes in the others before all the potential capacity benefits can be realized. Resolving the problem of delay requires an integrated approach that develops capacity improvements throughout the aviation system, while at the same time maintaining or improving the current level of aviation safety. Improvements in capacity — constructing new runways and taxiways, installing enhanced facilities and equipment, applying new technologies — generally require long lead times. We must start preparing now for improvements that take 5 to 10 years to plan, develop, and implement.

Resolving the problem of delay requires an integrated approach that develops capacity improvements throughout the aviation system, while at the same time maintaining or improving the current level of aviation safety.

3. *FAA Aviation Forecasts, Fiscal Years 1994–2005*, FAA–APO 94–1, March 1994. The economic scenario used to develop the FAA Aviation Forecasts for the period 1994 through 1999 was provided by the Executive Office of the President, Office of Management and Budget (OMB). For the period from 2000 through 2005, the economic scenario used consensus growth rates of the economic variables, based on forecasts prepared by DRI/McGraw-Hill, Evans Econometrics, and the WEFA Group.

1.2 Aviation Capacity Enhancement Plan

The *Aviation Capacity Enhancement Plan* is an important part of Federal Aviation Administration (FAA) and Department of Transportation (DOT) efforts to improve the Nation's transportation system. The Secretary of Transportation's *National Transportation Policy* (NTP) describes the enormity of the Nation's transportation infrastructure needs and sets as a major theme the need to maintain and expand the national transportation system. The *Federal Aviation Administration Strategic Plan*, based on the NTP, provides the long-term goals and objectives towards which the FAA is working. The newly developed FAA Operational Concept bridges the gap between the broad policies and strategies of the FAA Strategic Plan and the specific actions and projects in the numerous operating-level plans throughout the FAA. The FAA Operational Concept delineates the operational capabilities that must be in place to achieve an operating vision of the future for the year 2010. The *Aviation Capacity Enhancement Plan* supports the key strategic issue of improving capacity and access.

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The *Aviation Capacity Enhancement Plan* identifies the causes of delay and quantifies its magnitude.

The *Aviation Capacity Enhancement Plan* is also linked to other FAA operating-level plans. In particular, it addresses requirements for research, for facilities and equipment, and for airport improvements that can be funded from the FAA's *Airport Improvement Program* (AIP). Each of these areas is addressed in a major FAA plan, and the *Aviation Capacity Enhancement Plan* generates requirements for each of those plans. *The Research, Engineering, and Development (RE&D) Plan* is used to determine which systems and technologies the FAA should use to accomplish agency goals and objectives. The RE&D Plan includes the research needed to validate the new instrument approach procedures detailed in Chapter 3. The *Capital Investment Plan* (CIP) provides a framework for investment in the facilities and equipment needed to improve the National Airspace System (NAS). The CIP funds the technological improvements described in Chapter 5. The *National Plan of Integrated Airport Systems* (NPIAS) presents airport improvement projects nationwide that are eligible for AIP funding. Among these are projects to build new airports and to improve existing airports to increase capacity and safety. These projects are discussed in Chapter 2.

The *Aviation Capacity Enhancement Plan* identifies the causes of delay and quantifies its magnitude. The plan catalogues and summarizes programs that have the potential to enhance capacity and reduce delay. Within the plan, these programs have been organized into broadly related categories that,

in turn, parallel chapter development: Airport Development, New Instrument Approach Procedures, Airspace Development, Technology for Capacity Improvement, and Marketplace Solutions.

1.3 Level of Aviation Activity

1.3.1 Activity Statistics at the Top 100 Airports

The top 100 airports in the United States, as measured by 1992 passenger enplanements, are shown in Figure 1-2.[4] These 100 airports accounted for over 92 percent of the 514.2 million passengers that enplaned nationally in 1992.

In 2005, 775 million domestic and international passengers are forecast to enplane at these airports.[5] This represents a projected growth in enplanements of nearly 64 percent over the 13 year period of the forecast, an average annual rate of growth of about 5 percent.

In 1992, over 25 million aircraft operations occurred at the top 100 airports. By 2005, operations are forecast to grow to approximately 35 million at these airports, a projected growth in operations of nearly 38 percent.

Operations data for 1991, 1992, and 1993 and enplanement data for 1991 and 1992, as well as forecasts of operations and enplanements for 2005 for the top 100 airports, are included in Appendix A.

The top 100 airports accounted for over 92 percent of the 514.2 million passengers that enplaned nationally in 1992.

4. The top 100 airports were chosen based on 1992 passenger enplanements as listed in preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

5. Based on preliminary data intended for the FAA's *Terminal Area Forecasts*. FY91 and FY92 operations and enplanement data for the top 100 airports, a forecast for the year 2005, and the percentage growth that the forecast represents are shown in Appendix A, as well as a ranking by percentage growth in operations and enplanements.

1.3.2 Traffic Volumes in Air Route Traffic Control Centers (ARTCCs)

In 1992, the total number of aircraft flying under IFR handled by all ARTCCs increased, but only by 0.8 percent compared to 1991, from 36.4 up to 36.7 million operations.

Center operations are forecast to increase from 36.7 million aircraft handled in 1992 to 46.5 million in 2005.

Air traffic volume statistics for 1992 show that instrument flight rules (IFR) operations increased at 11 of the 20 Continental United States (CONUS) ARTCCs over 1991. In 1992, the total number of aircraft flying under IFR handled by all ARTCCs increased, but only by 0.8 percent compared to 1991, from 36.4 up to 36.7 million operations.[6] Commercial aircraft handled at the centers increased by 1.3 percent, with commuter/air taxi activity up 5.4 percent, while general aviation and military activity remained static.

Aircraft operations at the centers are expected to grow at an average rate of 2.0 percent a year between 1992 and 2005.[7] In absolute numbers, center operations are forecast to increase from 36.7 million aircraft handled in 1992 to 46.5 million in 2005. In 1992, 49.9 percent of the traffic handled at centers were air carrier flights. This proportion is expected to increase only slightly to 51.4 percent in 2005.

Figure 1-3 provides a map of the 20 CONUS ARTCCs. Figure 1-4 compares the number of operations during FY91 and FY92 and provides a forecast for FY05 for each of the 20 CONUS ARTCCs. A breakdown by user group of the traffic handled by the centers in 1991 and 1992, operations data for the individual ARTCCs for 1991 and 1992, and forecasts for 2005 are included in Appendix A.

6. Based on FAA's Forecast of IFR Aircraft Handled by Air Route Traffic Control Centers 1993–2005, FAA-APO-93-4, May 1993.
7. Based on *FAA Aviation Forecasts, Fiscal Years 1994–2005*, FAA–APO 94–1, March 1994.

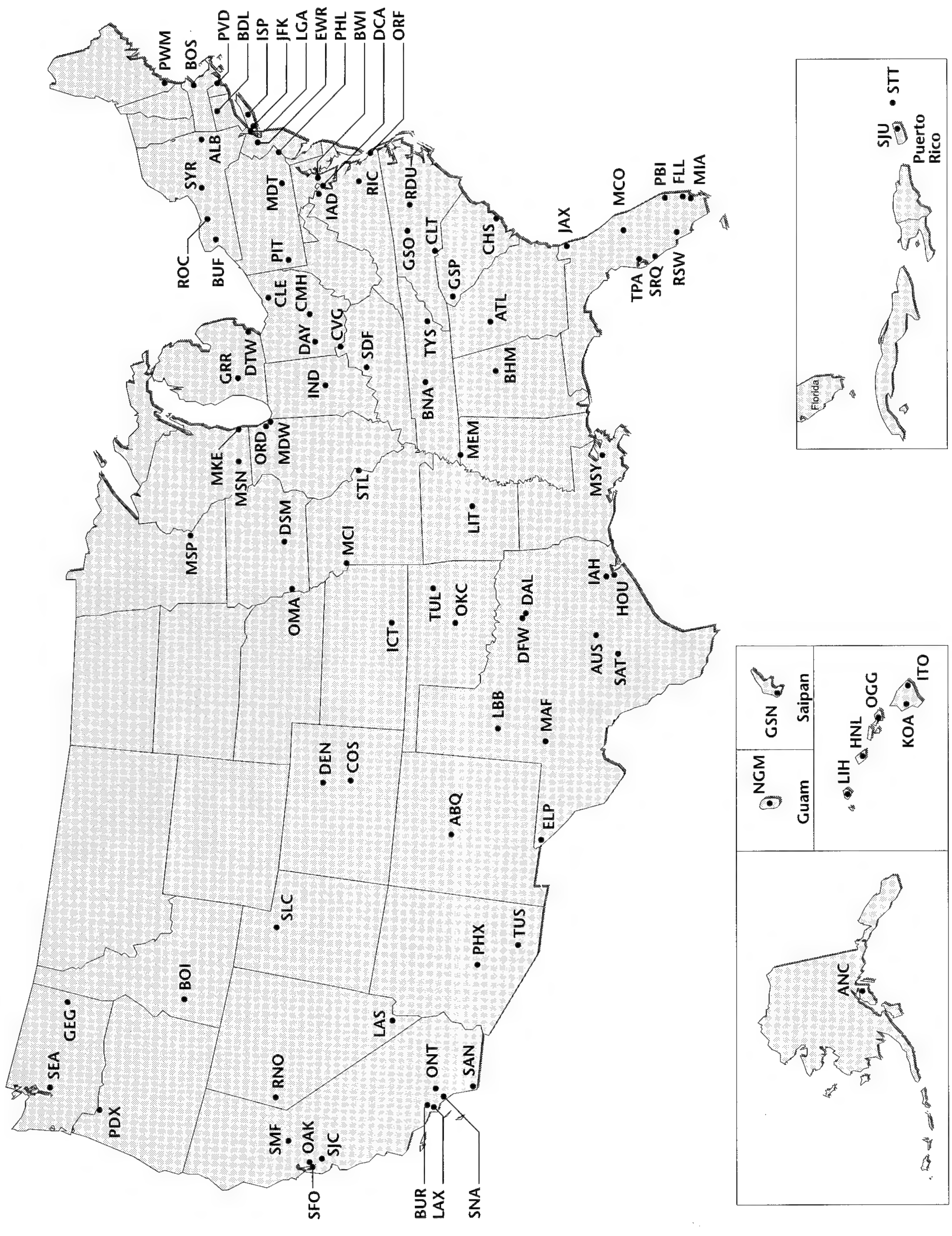


Figure 1-2. The Top 100 Airports by 1992 Enplanements

Source: FAA'S Terminal Area Forecasts

See Table A-6 in Appendix A for an alphabetic listing of the three-letter airport identifiers.

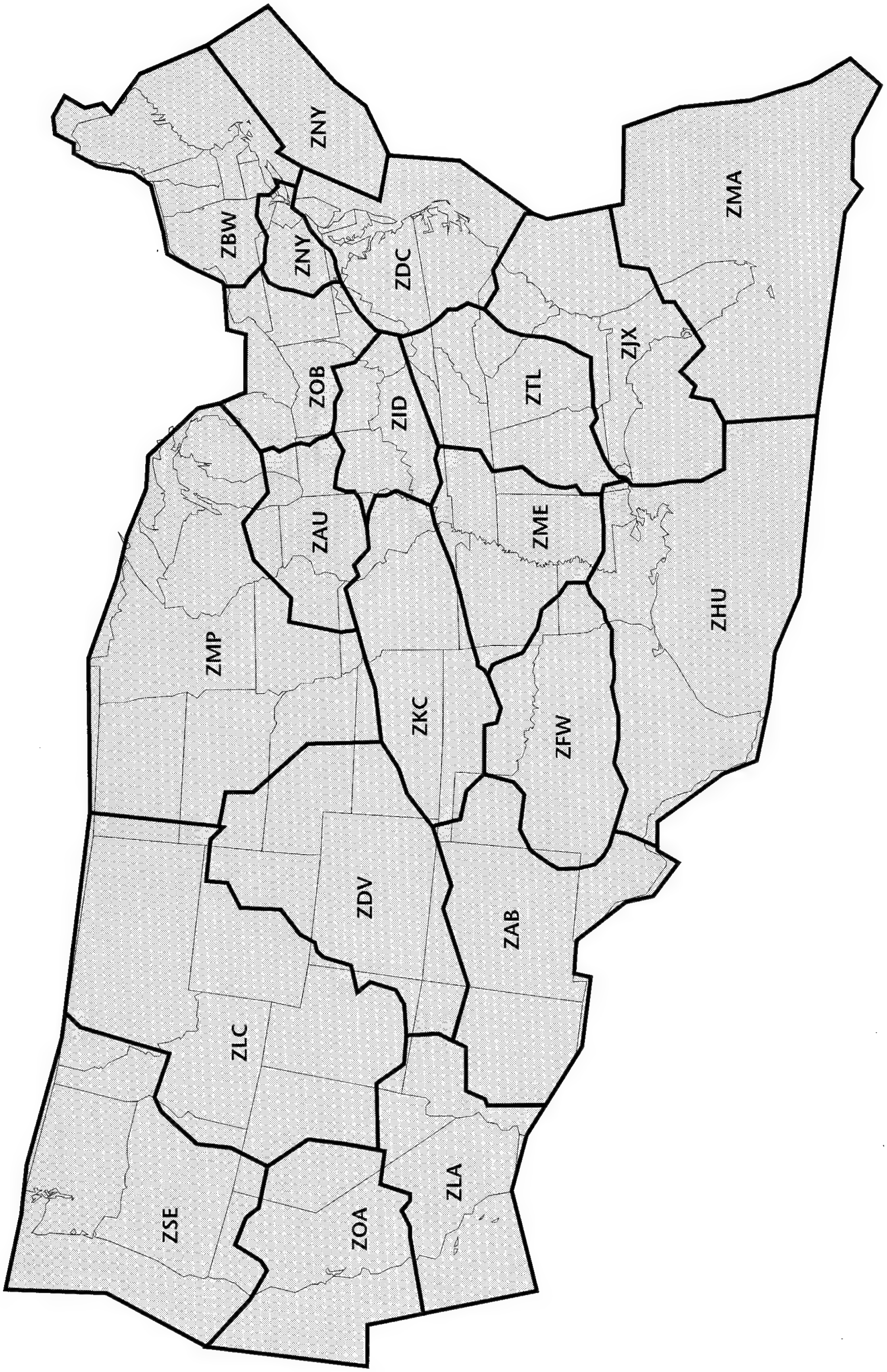


Figure 1-3. The 20 Continental U.S. Air Route Traffic Control Centers

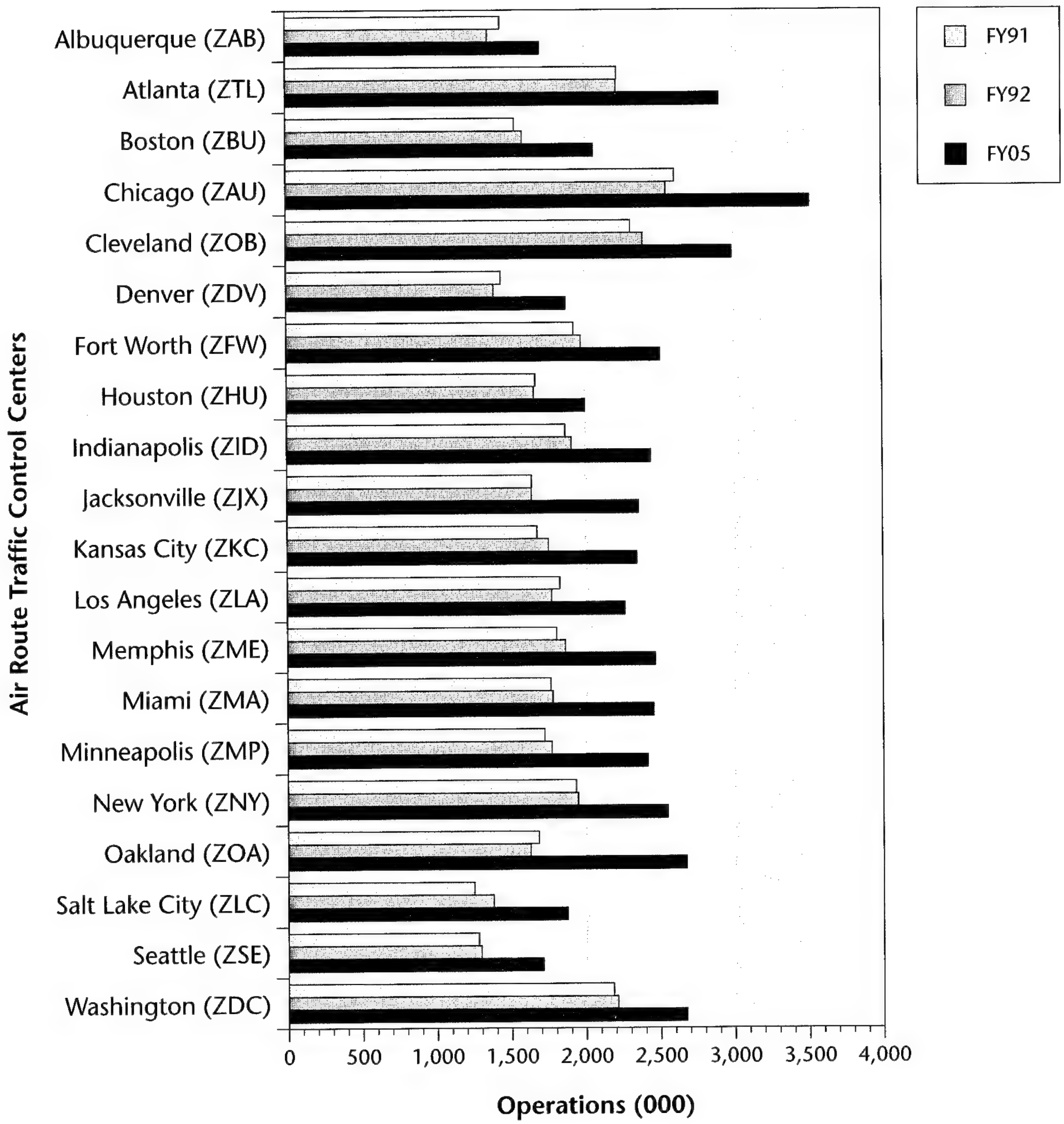


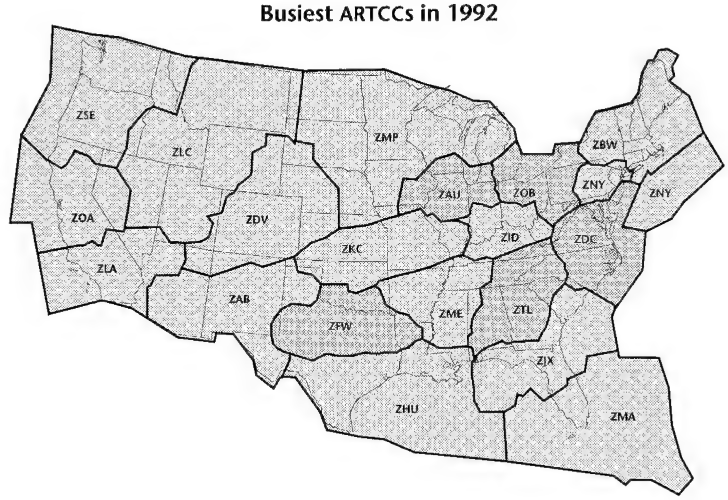
Figure 1-4. Operations at Air Route Traffic Control Centers
Source: Forecast of IFR Aircraft Handled by ARTCC, FY92-FY05, FAA-APO-93-4, May 1993

The busiest ARTCCs in 1992 were: Chicago, Cleveland, Atlanta, Washington, and Fort Worth. Forecasts for 2005 indicate a change in ranking of the busiest ARTCCs to: Chicago, Cleveland, Atlanta, Oakland, and Washington. The centers with the highest average annual growth rates are Oakland and Jacksonville, which are projected to grow by 3.9 and 2.8 percent respectively. The relatively high growth at these two centers reflects the projected high growth of domestic traffic demand in the West and South. Oakland Center is forecast to experience the largest absolute growth, from 1.6 million aircraft operations in 1992 to 2.7 million in the year 2005, a 64 percent increase. This reflects the continuing development and strong projected growth on trans-Pacific routes.

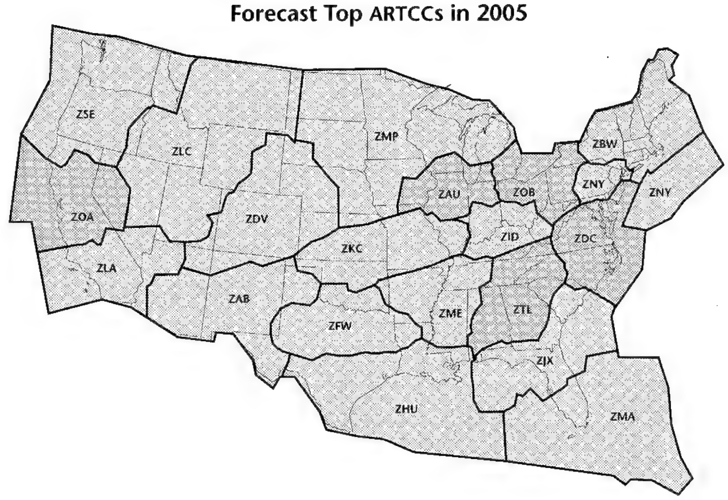
The busiest ARTCCs in 1992 were:
- Chicago,
- Cleveland,
- Atlanta,
- Washington, and
- Fort Worth.

Forecasts for 2005 indicate a change in ranking of the busiest ARTCCs to:
- Chicago,
- Cleveland,
- Atlanta,
- Oakland, and
- Washington.

Busiest ARTCCs in 1992



Forecast Top ARTCCs in 2005



1.4 Delay[8]

1.4.1 Sources of Delay Data

Delay can be thought of as another system performance parameter, an indicator that capacity is perhaps being reached and even exceeded. Currently, the FAA gathers delay data from two different sources. The first is through the Air Traffic Operations Management System (ATOMS), in which FAA personnel record aircraft that are delayed 15 or more minutes by specific cause (weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions). Aircraft that are delayed by less than 15 minutes are not recorded in ATOMS.

The FAA gathers delay data from two different sources. The first is through the Air Traffic Operations Management System (ATOMS), and the second source of delay data is through the Airline Service Quality Performance (ASQP) data.

The second source of delay data is through the Airline Service Quality Performance (ASQP) data, which is collected, in general, from airlines with one percent or more of the total domestic scheduled service passenger revenue[9] and represents delay by phase of flight (i.e., gate-hold, taxi-out, airborne, or taxi-in delays). Actual departure time, flight duration, and arrival times are reported along with the differences between these and the equivalent data published in the *Official Airline Guide* (OAG) and entered in the Computer Reservation System (CRS). ASQP delays range from 0 minutes to greater than 15 minutes. In the discussion that follows, "delay by cause" refers to ATOMS data, and "delay by phase of flight" refers to ASQP data.

The delay data reported through ATOMS and ASQP are not without their problems. ATOMS is the official FAA delay reporting system. However, it only reports delays of 15 minutes or more; it aggregates flight delays, thus making it impossible to determine if a particular flight was delayed; and it only reports flight delays due to an air traffic problem (i.e., weather, terminal volume, center volume, closed runways or taxiways, and NAS equipment interruptions). ASQP only reports on carriers with at least 1 percent of domestic passenger enplanements for scheduled air carrier flights. ASQP is used primarily for consumer on-time performance reporting and is under DOT control.

8. Although no existing delay reporting system is fully comprehensive, this Plan aims to identify problem areas through available data, such as the following delay information and the previously mentioned aviation activity statistics.

9. Airlines reporting ASQP data as of November 1, 1993 include: Alaska, American, America West, Continental, Delta, Northwest, Southwest, TWA, United, and USAir.

The FAA is developing an improved aircraft delay data system to provide a single, integrated source of data to answer analytical questions about delay at a detailed level. This new system, the Consolidated Operations and Delay Analysis System (CODAS), will use Enhanced Traffic Management System (ETMS), OAG, ASQP, and Aeronautical Radio Incorportated (ARINC) Communications Addressing and Reporting System (ACARS) data to calculate delay by phase of flight and will include weather data from the National Oceanic and Atmospheric Administration (NOAA) for analysis purposes. By combining, comparing, and screening the data from these sources, a refined data source is created, which can be used for accurate delay calculations and model validation. CODAS will not replace ATOMS, which will continue to be the official FAA delay reporting system.

The FAA is developing an improved aircraft delay data system to provide a single, integrated source of data to answer analytical questions about delay at a detailed level.

1.4.2 Delay by Cause

Flight delays exceeding 15 or more minutes, as recorded by ATOMS, were experienced on 275,759 flights in 1993, a decrease of 1.8 percent over 1992. Weather was attributed as the primary cause of 72 percent of operations delayed by 15 minutes or more in 1993, up from 65 percent in 1992. Terminal air traffic volume accounted for 22 percent of delays of 15 or more minutes, down from 27 percent in 1992. Table 1-1 details these and other factors that caused delays of 15 minutes or more and provides a history of this breakdown of delay by primary cause. With the exception of the split between terminal and center volume delays, the basic distribution of delay by cause has remained fairly consistent over the past seven years.

Flight delays exceeding 15 or more minutes, as recorded by ATOMS, were experienced on 275,759 flights in 1993, a decrease of 1.8 percent over 1992.

More than half of all delays are attributed to adverse weather. These delays are largely the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. The FAA continues to install new and upgrade existing instrument landing systems (ILSs) to support continued operations during conditions of reduced visibility. During the past few years, the FAA has developed new, capacity-producing approach procedures that take advantage of improving technology while maintaining the current level of safety. These new procedures, and a corresponding estimate of the expected increase in the number of operations per hour, are discussed in Chapter 3.

1.4.3 Delay by Phase of Flight

Based on ASQP data, Table 1-2 presents the average delay in minutes by phase of flight. This table shows, for example, that more delays occur during the taxi-out phase than any other phase and that airborne delays average 4.1 minutes per aircraft. To put this in perspective, there were approximately 6,200,000 air carrier flights in 1992.[10] With an average airborne delay of 4.1 minutes per aircraft, this means that there was a total of over 424,000 hours of airborne delay that year, which, at an estimated $1,600 per hour, cost the airlines $678 million.

Table 1-1. Distribution of Delay Greater Than 15 Minutes by Cause

Distribution of Delay Greater than 15 Minutes by Cause								
Cause	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Weather	67%	67%	70%	57%	53%	66%	65%	72%
Terminal Volume	16%	11%	9%	29%	36%	27%	27%	21%
Center Volume	10%	13%	12%	8%	2%	0%	0%	0%
Closed Runways/Taxiways	3%	4%	5%	3%	4%	3%	3%	3%
NAS Equipment	3%	4%	3%	2%	2%	2%	2%	2%
Other	1%	1%	1%	1%	3%	2%	3%	2%
Total Operations Delayed (000s)	**418**	**356**	**338**	**394**	**393**	**298**	**281**	**276**
Percent Change from Previous Year	+25%	-15%	-5%	+17%	0%	-24%	-6%	-2%

10. *FAA Aviation Forecasts, Fiscal Years 1994–2005*, FAA–APO 94–1, March 1994.

Table 1-2. Average Delay by Phase of Flight[11]

Average Delay by Phase of Flight (minutes per flight)						
Phase	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**
Gate-hold	1.0	1.0	1.0	1.1	1.1	1.0
Taxi-out	6.8	7.0	7.2	6.9	6.9	6.9
Airborne	4.0	4.3	4.3	4.1	4.1	4.1
Taxi-in	2.1	2.2	2.3	2.2	2.2	2.2
Total	14.0	14.6	14.9	14.3	14.3	14.2
Mins./Op.	7.0	7.3	7.5	7.1	7.1	7.1

1.4.4 Identification of Delay-Problem Airports

In CY93, the number of airline flight delays of 15 minutes or more decreased compared to 1992 at 31 of the 55 airports at which the FAA collects air traffic delay statistics. Table 1-3 lists the number of operations delayed 15 minutes or more per 1,000 operations from 1990 to 1993 at 51 of these airports. These delays ranged from nearly 88 per 1,000 operations at Newark International Airport to 0.1 per 1,000 at San Antonio International Airport. Three of the top six airports in delays of 15 or more minutes were in the New York area. Table A-8 in Appendix A lists this same data for 22 of the 55 airports from 1985 to 1992.

In CY93, the number of airline flight delays of 15 minutes or more decreased compared to 1992 at 31 of the 55 airports. These delays ranged from nearly 88 per 1,000 operations at Newark to 0.1 per 1,000 at San Antonio.

11. **Gate-hold Delay:** The difference between the time that departure of an aircraft is authorized by ATC and the time that the aircraft would have left the gate area in the absence of an ATC gatehold.

    Taxi-out Delay: The difference between the time of lift-off and the time that the aircraft departed the gate, minus a standard taxi-out time established for a particular type of aircraft and airline at a specific airport.

    Airborne Delay: The difference between the time of lift-off from the origin airport and touchdown, minus the computer-generated optimum profile flight time for a particular flight, based on atmospheric conditions, aircraft loading, etc.

    Taxi-in Delay: The difference between touchdown time and gate arrival time, minus a standard taxi-in time for a particular type of aircraft and airline at a specific airport.

    Mins/op: Average delay in minutes per operation.

Table 1-3. Delays of 15 Minutes or More Per 1,000 Operations a the Top 100 Airports

Airport	ID	1990	1991	1992	1993
Newark Int'l.	EWR	84.90	67.30	83.50	87.90
Chicago O'Hare Int'l.	ORD	64.60	47.90	45.40	47.50
Boston Logan Int'l.	BOS	32.30	32.80	34.60	39.20
New York LaGuardia	LGA	86.80	61.60	55.20	38.30
Denver Stapleton Int'l.	DEN	28.90	28.40	26.30	37.90
New York Kennedy Int'l.	JFK	68.30	41.70	41.20	35.70
Dallas-Fort Worth Int'l.	DFW	32.00	35.30	29.80	33.70
San Francisco Int'l.	SFO	45.80	58.10	30.20	23.80
Atlanta Hartsfield Int'l.	ATL	44.10	22.10	29.90	23.30
St. Louis Lambert Int'l.	STL	25.20	29.90	15.00	19.50
Philadelphia Int'l.	PHL	35.40	16.90	18.50	18.80
Miami Int'l.	MIA	8.60	24.00	9.70	10.50
Washington National	DCA	9.60	5.60	11.00	9.30
Los Angeles Int'l.	LAX	7.10	14.80	19.80	9.20
Detroit Metropolitan	DTW	19.90	9.30	11.20	9.10
Houston Intercontinental	IAH	12.70	12.60	7.90	8.10
Minneapolis-St. Paul Int'l.	MSP	31.90	7.90	4.40	7.20
Pittsburgh Int'l.	PIT	8.60	5.00	8.00	6.90
Washington Dulles Int'l.	IAD	7.40	9.00	7.30	6.90
Seattle-Tacoma Int'l.	SEA	30.50	18.80	13.20	6.80
Greater Cincinnati Int'l.	CVG	11.20	5.30	5.90	6.40
Orlando Int'l.	MCO	7.30	6.40	9.00	4.70
Baltimore-Washington Int'l.	BWI	17.60	6.00	5.80	3.90
Salt Lake City Int'l.	SLC	3.20	3.70	5.10	3.90
Tampa Int'l.	TPA	4.80	2.90	4.30	3.90
San Diego Int'l.	SAN	6.40	10.20	3.00	3.90
Charlotte/Douglas Int'l.	CLT	12.60	9.70	6.20	3.80
Fort Lauderdale-Hollywood Int'l.	FLL	3.00	2.10	3.70	3.80
Houston William B. Hobby	HOU	4.60	5.00	2.70	3.50
Chicago Midway	MDW	7.10	2.10	2.10	3.00
Phoenix Sky Harbor Int'l.	PHX	9.90	6.70	8.20	2.90
Nashville Int'l.	BNA	1.70	3.90	2.90	2.70
Cleveland Hopkins Int'l.	CLE	4.70	2.00	1.60	2.40
Raleigh-Durham Int'l.	RDU	2.40	2.00	3.60	2.00
Portland Int'l.	PDX	1.30	1.40	1.80	1.90
Kansas City Int'l.	MCI	2.30	3.00	0.80	1.30
Ontario Int'l.	ONT	1.20	1.60	1.30	1.20
Memphis Int'l.	MEM	3.00	2.40	1.10	1.00
Bradley Int'l.	BDL	3.80	2.40	2.00	0.90
Palm Beach Int'l.	PBI	1.40	1.50	1.00	0.80
Anchorage Int'l.	ANC	2.00	1.30	0.30	0.70
Indianapolis Int'l.	IND	0.80	1.00	2.10	0.60
Las Vegas McCarran Int'l.	LAS	1.20	0.40	0.30	0.50
San Jose Int'l.	SJC	11.10	4.30	1.70	0.40
Albuquerque Int'l.	ABQ	1.00	0.70	0.70	0.30
New Orleans Int'l.	MSY	2.00	1.10	0.60	0.30
San Juan Luis Muñoz Marín Int'l.	SJU	0.40	0.10	0.60	0.30
Dayton Int'l.	DAY	1.50	1.10	0.30	0.30
Honolulu Int'l.	HNL	0.40	0.40	0.10	0.20
San Antonio Int'l.	SAT	0.80	0.30	0.20	0.10
Kahului	OGG	0.20	0.10	0.10	0.00

1.4.5 Identification of Forecast Delay-Problem Airports

Forecasts indicate that, without capacity improvements, delays in the system will continue to grow. In 1993, 23 airports each exceeded 20,000 hours of annual aircraft flight delays. Assuming no improvements in airport capacity are made, 32 airports are forecast to each exceed 20,000 hours of annual aircraft flight delays by the year 2003. Table 1-4 lists the airports with 1993 actual and 2003 forecast air carrier delay hours in excess of 20,000 hours. The current forecast for 32 delay-problem airports in 2003 is eight less than the 40 airports predicted in the forecast of three years ago. This reflects the overall decline in air travel as a result of the recession, and an economic recovery that has been slower than expected.

Figure 1-5 shows the airports exceeding 20,000 hours of annual aircraft delay in 1993 and the airports forecast to exceed 20,000 hours of annual aircraft delay in 2003, assuming there are no capacity improvements.

Table 1-4. 1993 Actual and 2003 Forecast Air Carrier Delay Hours

Annual Aircraft Delay in Excess of 20,000 Hours					
1993		2003			
Atlanta Hartsfield	ATL	Atlanta Hartsfield	ATL	New York La Guardia	LGA
Boston Logan	BOS	Nashville	BNA	Orlando	MCO
Charlotte/Douglas	CLT	Boston	BOS	Memphis	MEM
Washington National	DCA	Baltimore Washington	BWI	Miami	MIA
Denver Stapleton	DEN	Charlotte-Douglas	CLT	Minneapolis-Saint Paul	MSP
Dallas-Ft. Worth	DFW	Cincinnati	CVG	Ontario	ONT
Detroit	DTW	Washington National	DCA	Chicago O'Hare	ORD
Newark	EWR	Dallas-Ft. Worth	DFW	Philadelphia	PHL
Honolulu	HNL	Detroit	DTW	Phoenix	PHX
Houston Intercont'l	IAH	Newark	EWR	Pittsburgh	PIT
New York John F. Kennedy	JFK	Honolulu	HNL	Raleigh-Durham	RDU
Los Angeles	LAX	Washington Dulles	IAD	San Diego	SAN
New York La Guardia	LGA	Houston Intercont'l	IAH	Seattle-Tacoma	SEA
Orlando	MCO	New York John F. Kennedy	JFK	San Francisco	SFO
Miami	MIA	Las Vegas	LAS	Salt Lake City	SLC
Minneapolis-Saint Paul	MSP	Los Angeles	LAX	St. Louis	STL
Chicago O'Hare	ORD				
Philadelphia	PHL				
Phoenix	PHX				
Pittsburgh	PIT				
Seattle-Tacoma	SEA				
San Francisco	SFO				
St. Louis	STL				

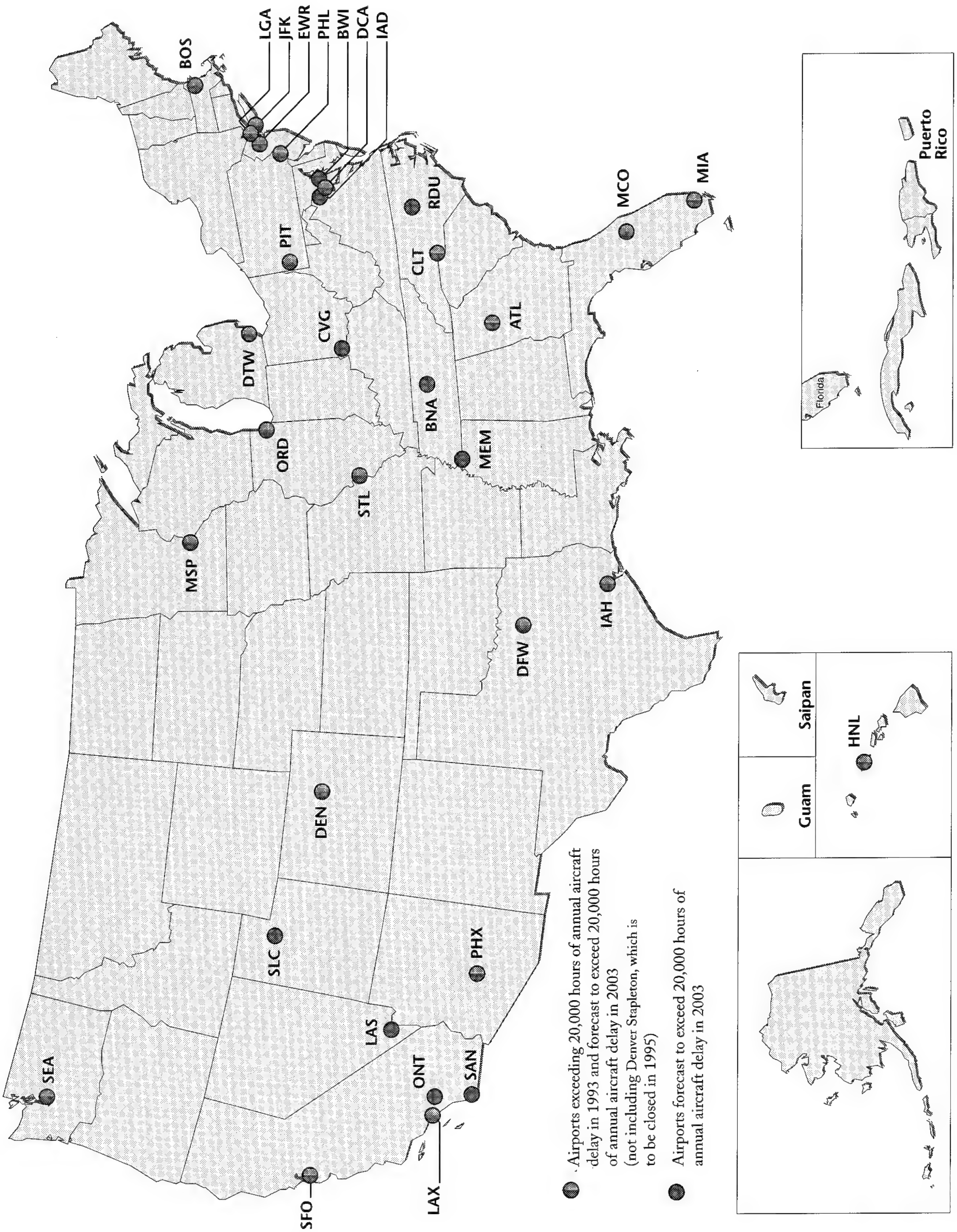


Figure 1-5. Airports Exceeding 20,000 Hours of Annual Delay in 1993 and 2003, Assuming No Capacity Improvements

Source: FAA Office of Policy and Plans

1.5 The FAA Strategic Plan and the FAA Operational Concept — A Vision for the Year 2010

A vigorous aviation system is essential for United States economic prosperity, and the entire aviation community must work together in order to maintain what has become the safest, most efficient, and most responsive aviation system in the world. To support this effort, the FAA developed the FAA Strategic Plan and the FAA Operational Concept. The two documents are a foundation for an iterative process to develop, in cooperation with all the users of the national aviation system, a common vision of the future from which to set policies, strategies, and operational goals for the year 2010.

In the year 2010, more people will be flying, more often, to more places than ever before. U.S. domestic passenger enplanements will double, and commuter and regional enplanements will triple. U.S. airlines will carry more than one billion passengers annually. Operations by general aviation aircraft will increase by 44 percent to 43 million flight hours annually. World revenue passenger miles will increase by 200 percent to reach 3.2 trillion. Larger aircraft sizes and higher load factors will combine to prevent even larger increases. Global air cargo revenue ton miles will grow by 136 percent reaching 130 billion. Helicopters and new tiltrotor and tiltwing aircraft will play an increasingly important role in providing short-haul and medium-range passenger service. The market for new aircraft over the next 20 years will be almost one trillion dollars, more than double the market over the past 20 years. The challenge for the year 2010 will be to ensure that flights are conducted with unprecedented levels of safety, security, and efficiency, while conserving natural resources and minimizing the effects on the environment.

The challenge for the year 2010 will be to ensure that flights are conducted with unprecedented levels of safety, security, and efficiency, while conserving natural resources and minimizing the effects on the environment.

1.5.1 System Capacity Goals and Objectives

The FAA Strategic Plan identifies System Capacity as one of seven strategic issue areas.

The general goal of the system capacity program is to build aviation system capacity that will minimize delays and allow fair access for all types of aviation.

The FAA Strategic Plan identifies System Capacity as one of seven strategic issue areas. The principal goals for the aviation system capacity program in Volume II of the FAA Strategic Plan are to ensure that:

- Airspace, airport, and airside capacity continue to grow to meet user needs cost effectively.
- Capacity resources are fully utilized to meet traffic demand and eliminate capacity-related delays.
- Airport capacities in instrument meteorological conditions (IMC) equal capacities in visual meteorological conditions (VMC).

Specific objectives have been developed in the FAA Strategic Plan to support the general goal of the system capacity program to build aviation system capacity that will minimize delays and allow fair access for all types of aviation. The FAA Operational Concept, in turn, lays out specific milestones the FAA will complete over the next five years to achieve these objectives.

- System Capacity Measurement — to identify and define, in concert with the aviation community, standards of success and national capacity indicators that will better target areas for reducing delay and increasing capacity.
- Near-Term Capacity Initiatives — to reduce constraints/limitations at the top 40 delay/operationally impacted airports by timely implementation of system enhancements and capacity increasing technologies and procedures.
- ATC Automation — to improve the automated infrastructure through replacement and enhancements in order to provide the platform for capacity-enhancing technologies and procedures.
- Traffic Flow Management — to create the necessary capabilities that will permit the ATC system to ensure safe separation while imposing minimum constraints on system users and aircraft movement.
- Oceanic Control — to change, in concert with the international aviation community, oceanic air traffic control from its current non-radar control to a tactical control environment much like current domestic radar control.
- Weather Forecasting, Detection, and Communication — to reduce the capacity-impacting consequences of

weather phenomena by improved weather forecasts and increased accuracy, resolution, and dissemination of observations both on the ground and in the air.

- Communications, Navigation, and Surveillance (CNS) and Satellite Navigation — to implement CNS and satellite navigation capabilities through an aggressive industry/government partnership that achieves user benefits in all phases of aviation operations.
- Communications/Data Link — to provide a cost-effective communications infrastructure to enhance the safety and effectiveness of air traffic management operations.
- Airport Planning — to improve the national airport planning process by adding a method for prioritizing projects; by linking the national plan to the grant program through an Airport Capital Improvement Program; and by developing the Airport Research, Engineering, and Development (RE&D) program.
- Human Factors — to implement new automation technologies and associated functional improvements in a manner that fully accounts for the proper role of the human in the system.

Chapter 2

Airport Development

2.1 Delay and the Need for Airport Development

Air traffic delay slipped temporarily from newspaper headlines, as a sluggish economy slowed growth in air transportation. The number of flights exceeding 15 minutes of delay has declined for the last three years, while commercial air carrier domestic passenger enplanements increased at an annual rate of less than 1 percent. However, air transportation has become a vital part of the United States economy. As the economic recovery gathers momentum, the demand for air travel will grow, and the number of aircraft operations will increase to meet that demand. Current forecasts indicate that, without capacity improvements, delays would increase substantially over the next decade, though at a somewhat slower pace than in the 1980s.

The number of flights exceeding 15 minutes of delay has declined for the last three years. As the economic recovery gathers momentum, the demand for air travel will grow, and aircraft operations will increase to meet demand. Current forecasts indicate that delays would increase substantially over the next decade.

The FAA's National Plan of Integrated Airport Systems (NPIAS) shows that, with the new improvements planned, capacity at the majority of the 29 "large hub" commercial service airports in the United States will be adequate to meet the forecast growth in demand. The few problem airports, which are predicted to continue to experience significant delay despite planned improvements, are primarily the large metropolitan area airports on the east and west coasts, principally in the Northeast and in California. At these problem airports, planned improvements are not adequate to meet the projected growth in demand, for a variety of reasons.

The positive message is that the capacity needed to meet future demand will be available at most of the Nation's busiest airports, if the improvements planned for these airports continue to be funded and built. It is, therefore, essential that the aviation community, in both the public and private sector, continues to work together to ensure that these improvement projects are completed in time to meet the growth in demand. However, the NPIAS points out that, even though capacity improvements are planned at the few delay-problem airports, they will not be enough to meet forecast demand at these airports. Delays there will most likely increase as demand increases.

The need for capacity improvement must continue to be emphasized so that projects will continue to be planned, funded, and built to keep pace with the projected demand.

From this perspective then, airport capacity improvements take on a two-tiered scheme of priorities. For most of the airports in the country, the need for capacity improvement must

continue to be emphasized so that projects will continue to be planned, funded, and built to keep pace with the projected demand. This has been the work of the Airport Capacity Design Teams, which is described in more detail in this chapter.

For the few delay-problem airports, renewed emphasis must be given to finding innovative solutions, with a view toward developing regional airport systems to serve the expanding air transportation needs.

For the few delay-problem airports in the Northeast, in California, and elsewhere, renewed emphasis must be given to finding innovative solutions. New airports, expanded use of existing commercial-service airports, civilian development of former military bases, and joint civilian and military use of existing military facilities—these options and more must be explored systematically with a view toward developing regional airport systems to serve the expanding air transportation needs of these large metropolitan areas.

An FAA report to Congress, *Long-Term Availability of Adequate Airport System Capacity* (DOT/FAA/PP-92-4, June 1992), describes the probable extent of airport congestion in the future, given current trends. The three assessment techniques used in the study all point to a persistent shortfall in capacity at some of the busiest airports in the country as airport development lags behind the growing demand for air travel. The report acknowledges that some of the shortfall may be corrected by such things as improvements in technology and demand management. However, a significant gap in airport capacity will probably remain, and a major increase in the rate of airport development may be needed, together with measures to maximize the efficient use of existing capacity, and, in the longer term, to supplement air transportation with high-speed ground transportation. High-speed ground transportation will be discussed further in Chapter 6, Marketplace Solutions. Development of new airports and options to maximize the efficiency of existing airports will be discussed in this and subsequent chapters.

2.2 New Airport Development

The largest aviation system capacity gains result from the construction of new airports.

The largest aviation system capacity gains result from the construction of new airports. The new Denver International Airport, for example, will increase capacity and reduce delays not only in the Denver area but also throughout the aviation system. However, at a cost of over $2.9 billion for a new airport like Denver, it will remain a challenge to finance and build others. In addition, the development of new airports faces environmental, social, and political constraints. Scheduled to be operational in 1995, Denver International Airport is the only major new airport currently under construction. Bergstrom AFB is currently the only major military airfield being converted for civilian use, designed to replace Austin Robert Mueller Airport. Table 2-1 summarizes other major new airports that have been considered in various planning studies by state and local government organizations.

Table 2-1 Major New Airports — Under Construction and Planning Studies

Airport	Purpose	Status
New Denver	Replacement airport for Denver Stapleton (DEN), which will close.	Under construction. Scheduled to be operational in 1995.
Dallas-Ft. Worth	Supplemental airport.	Phase 2 satellite study by North Central Texas Council of Governments.
Minneapolis-St. Paul	Replacement airport for MSP. Proposal is to close existing airport.	Dual track. Feasibility study for new airport. Capacity enhancement study for existing airport completed.
West Virginia	Regional Airport.	Feasibility study underway.
Chicago	Supplemental airport.	Master Plan/EA in progress on State of Illinois preferred alternative (Peotone). Estimated completion 1/96.
Seattle-Tacoma	Supplemental airport.	Feasability study underway by Puget Sound Regional Council.
Boston	No active plans for a new airport. Emphasis on greater use of existing outlying airports.	Based on new studies, MASPORT decided not to landbank a new airport.
Atlanta	Supplemental airport.	Satellite study by Atlanta Regional Commission of non-ranked sites completed. Feasibility study by State of Georgia underway.
Northwest Arkansas	Replacement airport for Fayetteville (FYV), which will remain in operation.	Site selection/AMP/EIS completed. Feasibility study completed. Record of Decision signed 8/16/94.
Birmingham, Alabama	Replacement airport. Proposal is to close existing airport.	Site selection completed. Ranked sites and preferred sites identified by State of Alabama.
North Carolina	Cargo/industrial airport.	An existing airport, Kinston, N.C., was selected as the prefered site. EIS process underway.
Eastern Virginia	Supplemental airport.	Regional study by three Councils of Governments.
Louisiana	Intermodal facility. Replacement airport for MSY and Baton Rouge (BTR). Existing airports will remain in operation.	New airport feasibility study by State of Louisiana. Phase 2 site selection study has been completed.
Austin	Replace Robert Mueller Airport.	Conversion of Bergstrom AFB to civil use. AIP Grant issued FY94 for demolition of existing structures for new airport.
Phoenix	Regional airport.	Feasibility study underway for Phoenix/Tucson regional airport.
St. Louis	Replacement airport on existing site.	Master Plan Update and EIS underway.
San Diego	Supplemental or replacement airport.	A series of studies indicated that a new airport is needed, but a site has not been selected yet.

2.3 Development of Existing Airports — Airport Capacity Design Teams

As environmental, financial, and other constraints continue to restrict the development of new airport facilities, an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the United States, an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities. In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at airports across the country affected by delay. Airport operators, airlines, and other aviation industry representatives work together with FAA representatives to identify and analyze capacity problems at each airport and recommend improvements that have the potential for reducing or eliminating delay. The FAA Technical Center's Aviation Capacity Branch (ACD-130), which has been involved in airport capacity simulation modeling since 1978, provides a ready source of technical expertise.

Aircraft flight delays are generally attributable to one or more conditions, which include weather, traffic volume, restricted runway capability, and NAS equipment limitations. Each of these factors can affect individual airports to varying degrees, but much delay could be eliminated if the specific causes of delay were identified and resources applied to develop the necessary improvements to remove or reduce the deficiency.

Since the renewal of the program in 1985, 34 Airport Capacity Design Team studies have been completed. Currently, three Capacity Team studies are in progress. Table 2-2 provides the status of the program at the airports with Airport Capacity Design Teams, and Figure 2-1 shows the location of each of these airports.

Table 2-2. Status of Airport Capacity Design Teams

Airport Capacity Design Team Status			
Completed			Ongoing
Atlanta	Orlando	Albuquerque	Portland
Boston	Philadelphia	Ft. Lauderdale	Seattle-Tacoma Update
Charlotte/Douglas	Phoenix	Indianapolis	Atlanta Update
Chicago	Pittsburgh	Houston Intercont.	
Detroit	Raleigh-Durham	Minneapolis-St. Paul	
Honolulu	Salt Lake City	Port Columbus	
Kansas City	San Antonio	Washington-Dulles	
Los Angeles	San Francisco	Oakland	
Memphis	San Jose	St. Louis	
Miami	San Juan, P.R.	New Orleans	
Nashville	Seattle-Tacoma	Eastern Virginia	
Cleveland	Las Vegas	Dallas/Ft. Worth	

As of 10-01-94

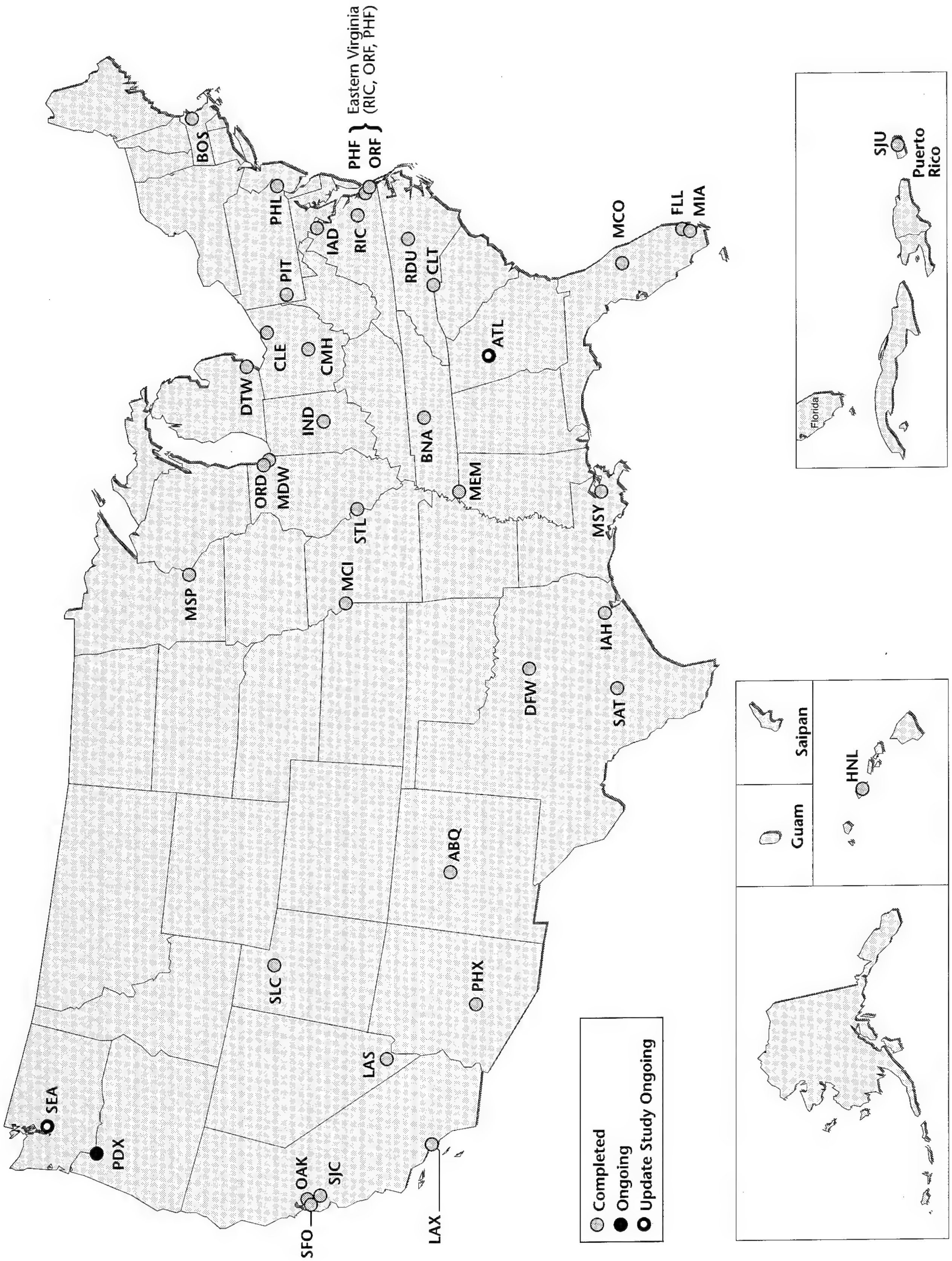


Figure 2-1. Airport Capacity Design Teams in the United States

2.3.1 Airport Capacity Design Teams — Recommended Improvements

Airport Capacity Design Teams identify and assess various corrective actions that, if implemented, will increase capacity, improve operational efficiency and reduce delay at the airports under study. These changes may include improvements to the airfield (runways, taxiways, etc.), facilities and equipment (navigational and guidance aids), and operational procedures. The Capacity Teams evaluate each alternative to determine its technical merits. Environmental, socioeconomic, and political issues are not evaluated here but in the master planning process. Alternatives are examined with the assistance of computer simulations provided by the FAA Technical Center at Atlantic City, New Jersey. In their final report, the Capacity Team recommends certain proposed projects for implementation. However, it should be noted that the presence of a recommended improvement in a Capacity Team report does not obligate the FAA to provide Facilities and Equipment (F&E) or Airport Improvement Program (AIP) funds. Demands for F&E and AIP funds exceed the FAA's limited resources and individual Capacity Team recommended projects must compete with all other projects for these limited funds.

Airport Capacity Design Teams identify and assess various corrective actions that, if implemented, will increase capacity, improve operational efficiency and reduce delay at the airports under study.

Airport Capacity Design Teams have developed more than 500 recommendations to increase airport capacity.

Table 2-3 summarizes these recommendations according to generalized categories of improvements. The Design Teams have developed more than 500 recommendations to increase airport capacity. Proposals to build a third or a fourth parallel runway were recommended by Design Teams at fourteen airports, proposals to build both a third and a fourth parallel runway were recommended at seven airports, proposals to build a new runway and a new taxiway were recommended at seven airports, proposals to build a new taxiway only were recommended at eleven airports, and proposals to build a new taxiway and new third and fourth parallel runways were recommended at five airports. Over half the capacity team reports have recommended proposed runway extensions, taxiway extensions, angled/improved exits, or holding pads/improved staging areas.

The only proposed facilities and equipment improvement that was recommended in more than half of the airport studies was the installation or upgrade of Instrument Landing Systems (ILSs) at one or more runways or runway ends, in order to improve runway capacity during IFR operations.

The proposed operational improvements that were recommended in half or more of the studies include improved IFR approach procedures and reduced separation standards for ar-

Capacity Team recommendations demonstrate the FAA's efforts to increase aviation system capacity by making the most use of current airports.

rivals. One-third of the studies recommended an airspace analysis or restructuring of the airspace. Enhancement of the reliever and general aviation (GA) airport system was recommended at more than half of the airports.

In general, the Capacity Team recommendations demonstrate the FAA's efforts to increase aviation system capacity by making the most use of current airports. In the view of the Airport Capacity Design Teams, the "choke point" most often is found in the runway/taxiway system. Where possible, the construction of a third and even a fourth parallel runway has been proposed. Runway and taxiway extensions, new taxiways, and improved exits and staging areas have been recommended to reduce runway occupancy times and increase the efficiency of the existing runways. In addition to maximizing use of airport land, airports are making the best use of facilities, equipment, and procedures to increase arrival capacity during IFR operations. Equipment is being installed to accommodate arrivals under lower ceiling and visibility minima, including ILSs, RVRs, and improved radar, not to mention new and improved arrival procedures and reduced separation standards for arrivals, both in-trail and laterally. Finally, in an effort to segregate larger jets from smaller/slower aircraft, the FAA is recommending enhancement of the reliever and general aviation airport system.

The typical Capacity Team will make 20 to 30 recommendations for improvements to reduce delay at each airport. In many cases, the recommended improvements to the airfield represent the biggest capacity gains, particularly since they frequently incorporate the benefits of improved procedures and upgraded navigational equipment.

2.3.2 Airport Capacity Design Teams — Potential Savings Benefits

As can be seen from the summary of Capacity Team recommendations in Table 2-3, the typical Capacity Team will make 20 to 30 recommendations for improvements to reduce delay at each airport. Because of the large number of specific improvements, it is virtually impossible to summarize the expected benefits of each of these recommendations for all the airports. In many cases, however, the recommended improvements to the airfield represent the biggest capacity gains, particularly since they frequently incorporate the benefits of improved procedures and upgraded navigational equipment. Detailed information on specific delay-savings benefits can be found in the final reports of the various Airport Capacity Design Teams.

Table 2-4 provides examples of the potential delay savings benefits of the airfield improvements recommended by the Capacity Teams. These savings benefits were drawn from the final reports of selected Airport Capacity Design Team studies. Delay savings are stated in millions of dollars and thousands of hours of delay saved at the highest future demand level considered by the Capacity Team. A breakdown of the summarized material and additional information is contained in Appendix F of this report.

Table 2-3. Summary of Capacity Design Team Recommendations

Airports / Recommended Improvements	Airfield Improvements	Construct third parallel runway	Construct fourth parallel runway	Relocate runway	Construct new taxiway	Runway extension	Taxiway extension	Angled exits/improved exits	Holding pads/improved staging areas	Terminal expansion	Facilities and Equipment Improvements	Install/upgrade ILSs	Install/upgrade RVRs	Install/upgrade lighting system	Install/upgrade VOR	Upgrade terminal approach radar	Install	Install PRM	New air traffic control tower	Wake vortex advisory system	Operational Improvements	Airspace restructure/analysis	Improve IFR approach procedures	Improve departure sequencing	Reduced separations between arrivals	Intersecting operations with wet runways	Expand TRACON/Establish TCA	Segregate traffic	De-peak airline schedules	Enhance reliever and GA airport system
Richmond						√		√				√	√	√									√		√					
Norfolk						√						√	√	√											√					
Newport News						√		√															√		√					
Washington-Dulles		√			√	√	√		√	√			√	√									√		√				√	√
Seattle-Tacoma		√						√				√								√			√		√				√	
San Juan, Puerto Rico					√		√	√	√	√				√	√				√	√					√					√
San Jose						√		√	√															√						
San Fransisco		√	√			√	√	√	√															√					√	√
San Antonio		√			√	√	√		√			√	√	√				√		√		√	√		√					√
Salt Lake City		√					√	√	√	√		√	√	√			√	√					√		√					√
St. Louis		√					√	√	√			√		√			√			√			√		√				√	
Raleigh-Durham		√	√	√	√			√	√			√	√				√			√		√	√		√		√			
Pittsburgh			√			√				√		√						√				√								
Phoenix		√			√		√	√	√	√		√		√	√								√	√	√			√	√	√
Philadelphia		√		√		√												√				√	√	√						
Orlando			√		√		√		√			√			√		√	√				√	√					√		√
Oakland					√			√	√																					
New Orleans					√										√				√			√	√		√					√
Nashville			√	√	√	√	√		√			√								√		√	√				√		√	√
Minneapolis-Saint Paul		√	√		√	√		√	√	√		√	√	√	√			√				√			√					√
Miami					√		√	√	√			√	√	√			√						√							√
Memphis		√			√	√	√	√				√											√		√				√	
Los Angeles					√	√	√		√	√		√							√			√								
Kansas City		√	√				√	√	√	√		√	√				√						√		√				√	
Indianapolis		√	√	√	√			√	√			√	√	√			√						√		√					√
Houston Intercontinental		√	√		√	√		√	√	√		√											√						√	√
Honolulu		√				√		√	√	√		√																	√	√
Fort Lauderdale					√	√		√	√	√		√			√	√		√		√		√	√		√				√	√
Port Columbus		√	√	√	√	√		√	√	√		√		√			√	√	√			√	√		√				√	√
Cleveland		√		√	√	√	√	√		√		√			√			√					√	√	√					√
Chicago O'Hare				√	√	√		√	√			√											√			√				
Chicago Midway					√	√			√														√		√					
Charlotte-Douglas		√				√	√	√	√			√		√			√	√								√	√			√
Boston					√	√	√	√	√			√								√			√			√				
Atlanta					√			√	√	√		√	√	√		√	√			√					√				√	
Albuquerque					√	√	√	√	√	√		√			√								√		√					√

Table 2-4. Potential Savings Benefits from Airfield Improvements Recommended by Airport Capacity Design Teams

Airport Design Team	Major Recommended Improvements	Demand		Future 2 Savings	
		Baseline	Future 2	Hours	Dollars (M)
Fort Lauderdale-Hollywood	Extend runway and improve exits.	219,000	350,000	20,804	$32.5
Honolulu	Extend existing runway, construct new parallel runway, and improve exits.	407,000	700,000	457,730	$891.2
Houston Intercontinental	Extend existing runway, construct new third and fourth parallel runways, and improve taxiway and exit system.	334,000	650,000	1,267,000	$2,221.1
Los Angeles	Construct departure pads, construct new terminals and gates, and improve exits and taxiways.	641,751	782,056	69,451	$145.8
Minneapolis-Saint Paul	Construct new runway, construct third parallel runway, and improve exits and taxiways.	420,390	600,000	62,675	$90.7
Nashville	Relocate runway, extend existing runways, construct new parallel runway, and improve taxiways.	266,000	534,000	23,424	$23.9
Philadelphia	Construct new commuter runway and relocate and extend existing runways.	410,000	565,000	154,624	$215.4
Greater Pittsburgh	Build third and fourth parallel runways.	471,000	618,000	126,000	$129.0

Note: The potential annual delay savings in hours and dollars shown in the table represent the sum of the estimated savings benefits of the major recommended airfield improvements for each airport's Baseline and Future 2 demand levels. However, the savings benefits of these individual alternatives are not necessarily additive. They have been totaled here only to give an approximation on a single page of the impact these improvements could have in reducing delay at these airports.

It should also be noted that the particular combination of computer models and analytic methods used to calculate the annual delay costs and benefits is unique to each airport. Therefore, it is difficult, if not impossible, to compare one airport to another.

See Appendix F for a more detailed breakdown of the material summarized in this table.

2.4 Construction of New Runways and Runway Extensions

The construction of new runways and extension of existing runways are the most direct and significant actions that can be taken to improve capacity at existing airports. Large capacity increases, under both visual flight rules (VFR) and instrument flight rules (IFR), come from the addition of new runways that are properly placed to allow additional independent arrival/departure streams. The resulting increase in capacity is from 33 percent to 100 percent (depending on whether the baseline airport has a single, dual, or triple runway configuration).

Sixty of the top 100 airports have proposed new runways or runway extensions to increase airport capacity.[1] Fifteen of the 23 airports exceeding 20,000 hours of air carrier flight delay in 1993[2] are in the process of constructing or planning the construction of new runways or extensions of existing runways. Of the 32 airports that are forecast to exceed 20,000 hours of annual air carrier delay in 2003, if no further improvements are made, 24 propose to build new runways or runway extensions.[3]

Figure 2-2 shows which of the top 100 airports are planning new runways or runway extensions. Figure 2-3 shows which of the airports forecast to exceed 20,000 hours of annual delay in 2003 are planning new runways or runway extensions. Table 2-5 summarizes new runways and runway extensions that are planned or proposed at the top 100 airports. The "generic" hourly IFR capacities included in Table 2–5 have been developed only to provide a common basis for comparing one airport configuration to another. They serve to illustrate the size of the capacity increases provided. These generic estimates should not be taken as the exact capacity of a particular airport. The total anticipated cost of completing these new runways and runway extensions exceeds $9.0 billion.

The construction of new runways and extension of existing runways are the most direct and significant actions that can be taken to improve capacity at existing airports.

Sixty of the top 100 airports have proposed new runways or runway extensions to increase airport capacity. Fifteen of the 23 airports exceeding 20,000 hours of air carrier flight delay in 1993 are in the process of constructing or planning the construction of new runways or extensions of existing runways.

1. Airports with runway projects are pictured in Figures 2-2 and 2-3 and summarized in Table 2-5, with the projected IFR capacity benefit, the estimated project cost (to the nearest million), and an estimated operational date. The single figure of IFR capacity benefit does not reflect all of the many significant capacity benefits resulting from this new construction, but it does provide a common benchmark for comparison.
2. At a cost of $1,600 in airline operating expenses per hour of airport delay, 20,000 hours of flight delay translates into $32 million per year.
3. As reflected in Figure 2-3.

In 1992, Colorado Springs completed construction of a new 13,500 foot parallel runway, and Nashville and Washington Dulles completed runway extensions. In 1993, Detroit Metropolitan Wayne County completed construction of a new 8,500 foot parallel runway, and runway extensions were completed at Dallas-Fort Worth, San Jose, Kailua-Kono Keahole, and Islip Long Island Mac Arthur. In 1993, Salt Lake City and Memphis began construction of independent parallel runways, and Louisville Standiford Field began construction of two independent parallel runways. In 1994, Jacksonville opened the first 6,000 feet of a new parallel runway, and Kansas City completed construction of a new 9,500 foot independent parallel runway.

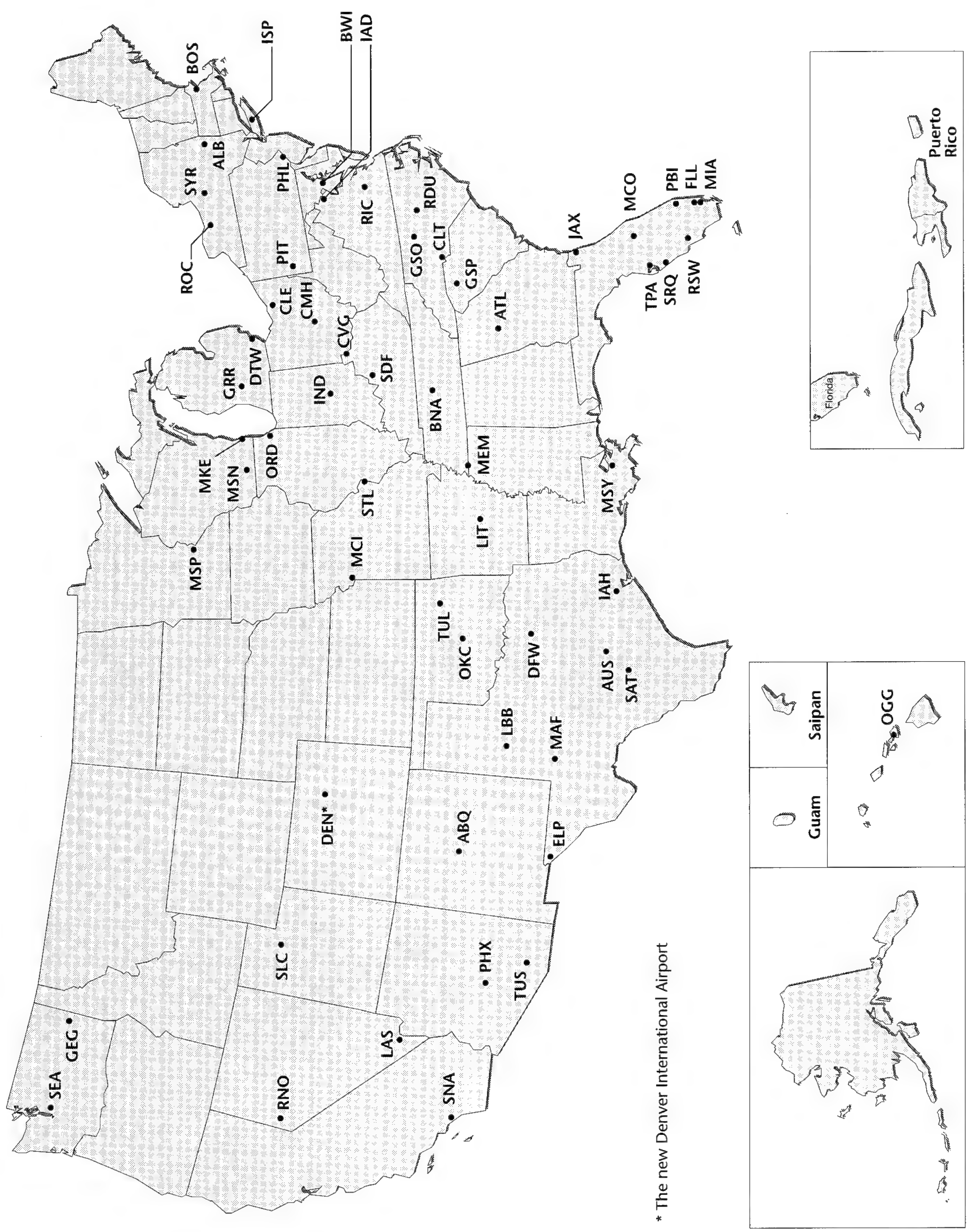


Figure 2-2. New Runways or Runway Extensions Planned or Proposed Among the Top 100 Airports

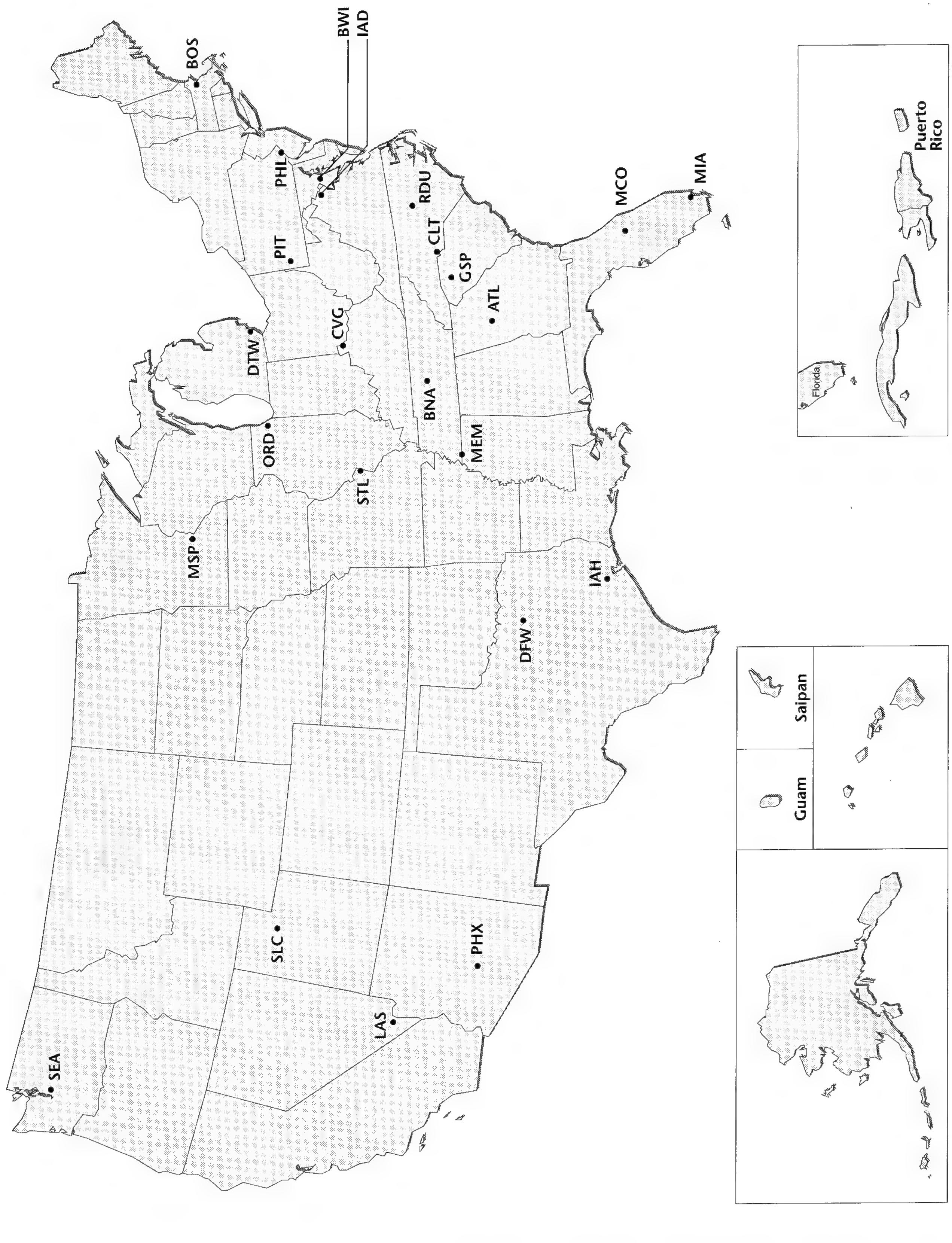


Figure 2-3. New Runways or Extensions Planned/Proposed Among the Airports Forecast to Exceed 20,000 Hours of Annual Aircraft Delay in 2003

Table 2-5. New and Extended Runways Planned or Proposed[+]

Airport	Runway	IFR Capacity (ARR/HR)[†] New Config.	IFR Capacity (ARR/HR)[†] Current Best	Est. Cost ($M)	Est. Date Oper.
Albany (ALB)	10/28 extension	29[2]	29[2]	$5.8	2005
	1R/19L parallel	++	29[2]	$7.5	2010
Albuquerque (ABQ)	3/21 extension	29[2]	29[2]	$20.0	1996
Atlanta (ATL)	E/W parallel	86[3]	57[1]	$160.0	1999
Austin (BSM) (new airport)	(Bergstrom AFB)	57[1]		$583.0	1998
Baltimore (BWI)	10R/28L parallel	57[11]	29[2]	$48.0	1996
	10/28 extension	29[2]	29[2]	$12.0	2003
Boston (BOS)	14/32	57[11]	29[2]	$5.0	1999
Charlotte (CLT)	18W/36W parallel	86[3]	57[1,8]	$43.0	1999
	18E/36E parallel	114[10]	57[1,8]		
Chicago O'Hare (ORD)	9/27 parallel	86[3]	57[1]		
	14/32 parallel	86[3]	57[1]		
	14L extension	57[1]	57[1]		
Cincinnati (CVG)	18R/36L extension	57[1,8]	57[1]	$11.0	1997
	9/27 extension	57[1,8]	57[1]	$25.0	1995
Cleveland-Hopkins (CLE)	5L/23R extension	29[2]	29[2]	$50.0	1999
	5W/23W parallel	42[4]	29[2]	$125.0	2000
Port Columbus (CMH)	10L/28R extension	42[4]	42[4]	$21.2	1998
	10S/28S parallel	57[11]	42[4]	$108.1	
	10N/28N parallel	57[1]	42[4]	$49.4	
Dallas-Fort Worth (DFW)	17R/35L extension	57[1]	57[1,7]	$20.0	1993
	18L/36R extension	57[1]	57[1,7]	$25.0	1997
	18R/36L extension	57[1]	57[1,7]	$24.0	1997
	16E/34E	86[3]	57[1,7]	$320.0	1996
	16W/34W	114[10]	57[1,7]	$150.0	2001
Denver (DEN)	New airport	86[3]	57[1]	$2,972.0	1995
Detroit (DTW)	4/22 parallel	71[6]	57[1]	$54.5	1998
El Paso (ELP)	8/26 parallel	++	29[2]	$10.7	
Fort Lauderdale (FLL)	9R/27L extension	42[4]	42[4]	$270.0	2000
Fort Myers (RSW)	6/24 extension	29[2]	29[2]	$20.0	1994
	6R/24L parallel	57[1]	29[2]	$87.0	2000

Table 2-5. New and Extended Runways Planned or Proposed[+]

Airport	Runway	IFR Capacity (ARR/HR)[†] New Config.	Current Best	Est. Cost ($M)	Est. Date Oper.
Grand Rapids (GRR)	8L/26R extension	29[2]	29[2]	$3.6	1994
	17/35 replacement	29[2]	29[2]	$40.0	1998
	8L/26R parallel	57[1]	29[2]		
Greensboro (GSO)	5L/23R parallel	57[1]	29[2]		
	14/32 extension	29[2]	29[2]	15.7	1998
Greer (GSP)	3R/21L parallel	57[1]	29[2]	$50.0	2015
	3L/21R extension	29[2]	29[2]	$34.1	1999
Houston (IAH)	14R/32L extension	57[1]	57[1]	$8.0	1997
	8L/26R parallel	86[3]	57[1]	$44.0	1999
	9R/27L parallel	114[10]	57[1]	$44.0	2002
Indianapolis (IND)	5L/23R replacement	57[1]	42[4]	$37.5	1995
Islip (ISP)	15R/33L extension	29[2]	29[2]	$26.0	2000
Jacksonville (JAX)	7R/25L parallel	57[1]	29[2]	$37.0	2000
	7L/25R extension	29[2]	29[2]	$19.0	1994
Kahului (OGG)	2/20 extension	29[2]	29[2]		
Kansas City (MCI)	1R/19L parallel	57[1]	29[2]	$45.2	1994
	1L/19R extension	29[2]	29[2]	$7.0	
Las Vegas (LAS)	7R/25L extension	29[2]	29[2]	$3.2	1995
	1L/19R reconstruction	29[2]	29[2]		1997
Little Rock (LIT)	4L/22R extension	57[1]	57[1]	$30.0	1996
Louisville (SDF)	17L/35R parallel	29[2]	29[2]	$42.0	1995
	17R/35L parallel	57[1]	29[2]	$51.0	1997
Lubbock (LBB)	8/26 extension	29[2]	29[2]	$3.8	2000
Madison (MSN)	3/21 Replacement	29[8]	29[8]	$15.0	1998
Memphis (MEM)	18E/36E parallel	57[1]	42[4]	$88.8	1997
	18L/36R extension	42[4]	42[4]	$58.0	1999
Miami (MIA)	9N/27N parallel	++	57[1]	$170	1999
Midland (MAF)	10/28 extension	29[2]	29[2]	$5.0	2005
Milwaukee (MKE)	7R/25L parallel	57[7]	29[2]	$150.0	2003
Minneapolis (MSP)	4/22 extension	42[4]	42[4]	$12.5	1995
Nashville (BNA)	2E/20E parallel	++	57[1]		
	2R/20L extension	57[1]	57[1]	38.6	2000

Table 2-5. New and Extended Runways Planned or Proposed[+]

Airport	Runway	IFR Capacity (ARR/HR)[†] New Config.	Current Best	Est. Cost ($M)	Est. Date Oper.
New Orleans (MSY)	1L/19R parallel	57[1]	29[2]	$340.0	2000
	10/28 parallel	57[1]	29[2]	$460.0	2020
Oklahoma City (OKC)	17L/35R extension	57[1]	57[1]	$8.0	
	17R/35L extension	57[1]	57[1]	$8.0	2014
	17W/35W parallel	57[1]	57[1]	$13.0	2004
Orlando (MCO)	17L/35R 4th parallel	86[3]	57[1]	$115.0	2000
Palm Beach (PBI)	9L/27R extension	29[2]	29[2]	$4.8	
	13/31 extension	29[2]	29[2]	$1.0	1999
	9R/27L extension	29[2]	29[2]	$0.5	1999
Philadelphia (PHL)	8/26 parallel-commuter	57[1,9]	57[7]	$215.0	1997
Phoenix (PHX)	7/25 3rd parallel	57[1]	42[4]	$88.0	1995
	8L/26R extension	42[4]	42[4]	$7.0	
Pittsburgh (PIT)	10C/28C extension	57[1]	57[1]	$10.0	1995
	4th parallel 10/28	71[6]	57[1]	$150.0	2000
	5th parallel 10/28	++	57[1]		
Raleigh-Durham (RDU)	Relocate 5R/23L	57[1]	57[11]		
	5W/23W	++	57[11]		
	5E/23E	++	57[11]		
Reno (RNO)	16L/34R extension	29[2]	29[2]	$22.0	1994
Richmond (RIC)	16/34 extension	29[2]	29[2]	$12.0	1997
Rochester (ROC)	4R/22L parallel	++	29[2]	$10.0	2010
	4/22 extension	29[2]	29[2]	$4.0	2000
	10/28 extension	29[2]	29[2]	$3.2	2000
St. Louis (STL)	14R/32L	++	29[2]	$390.0	1998
Salt Lake City (SLC)	16/34 west parallel	57[1]	42[4]	$120.0	1996
San Antonio (SAT)	N/S parallel	++	29[2]	$300.0	2005
Santa Ana (SNA)	1L/19R extension	29[2]	29[2]		
Sarasota-Bradenton (SRQ)	14L/32R parallel	57[1]	29[2]	$9.0	1998
	14/32 extension	29[2]	29[2]	$4.3	1996
Seattle-Tacoma (SEA)	16W/34W parallel	42[4]	29[2]	$400.0	2001
Spokane (GEG)	3L/21R	57[1]	29[2]	$11.0	2001
Syracuse (SYR)	10L/28R	57[1]	29[2]	$46.0	2000

Table 2-5. New and Extended Runways Planned or Proposed+

Airport	Runway	IFR Capacity (ARR/HR)† New Config.	Current Best	Est. Cost ($M)	Est. Date Oper.
Tampa (TPA)	18R/36L 3rd parallel	71[6]	57[1]	$55.0	2000
	27 extension	57[1]	57[1]		
	18L extension	57[1]	57[1]		
Tucson (TUS)	11R/29L parallel	29[2]	29[2]	$30.0	2005
Tulsa (TUL)	18E/36E parallel	86[3]	57[1]	$115.0	2005
Washington (IAD)	1L/19R parallel	86[3]	57[1,7]	$60.0	2009
	12R/30L parallel	57[1]	57[1,7]	$80.0	2010
Total Available Estimated Costs of Construction:				**$9.3 Billion***	

\+ See endnotes 1-11, below, which describe the IFR arrival capacity of the current and potential new configurations.

++ Information on runway location is unavailable or too tentative to determine IFR multiple approach benefit of this new construction project.

* Includes the total costs of the new Denver International Airport, $2,972 million.

† Estimates of generalized hourly IFR arrival capacity increases are included in Table 2–5. These values have been updated from those originally reported in a 1987 report. The new numbers reflect the approval of 2.5 (for wet runways inside 10 nm), 3, 4, 5, and 6 nm in-trail separations and 1.5 nm diagonal separation for dependent parallel arrivals. The updated IFR arrival capacity of any single runway that can be operated independently is 29 arrivals per hour (rounded up from 28.5); dependent parallel runways, 42 arrivals per hour; and independent parallels, 57 arrivals per hour (2 times a single runway, 28.5). Other configurations are multiples of the above. These values are provided to illustrate the approximate magnitude of the capacity increase provided. They should not be taken as the exact capacity of a particular airport, since site-specific conditions (e.g., varying aircraft fleet mixes) can result in differences from these estimates.

Endnotes

1. Independent parallel approaches [57 IFR arrivals per hour].
2. Single runway approaches [29 IFR arrivals per hour {rounded up from 28.5}].
3. Triple independent approaches (currently not authorized) [86 IFR arrivals per hour {rounded up from 85.5}].
4. Dependent parallel approaches [42 IFR arrivals per hour].
5. Triple approaches with parallel and converging pairs may permit more than 57 IFR arrivals if procedures are developed.
6. Triple parallel approaches with dependent and independent pairs (currently not authorized) [71 IFR arrivals per hour {This is a rough estimate, obtained by adding 42 & 29 as explained above}].
7. Converging IFR approaches to minima higher than Category (CAT) I ILS [57 IFR arrivals per hour].
8. Added capacity during noise abatement operations.
9. Independent parallel approaches with one short runway.
10. If independent quadruple approaches are approved [114 IFR arrivals per hour].
11. Independent parallel approaches with PRM (3,400 ft. to 4,300 ft.) [57 IFR arrivals per hour].

2.5 Airport Tactical Initiatives

The recommendations by Airport Capacity Design Teams have emphasized constructing new runways and taxiways, extending existing runways, installing enhanced facilities and equipment, and modifying operational procedures. These improvements are normally implemented through established, long-term procedures. The Office of System Capacity and Requirements (ASC) has recently initiated an effort to identify, evaluate, and implement capacity improvements that are achievable in the near term and will provide more immediate relief for chronic delay-problem airports. Tactical Initiative Teams, made up of representatives from airport operators, air carriers, other airport users, and aviation industry groups together with FAA representatives, are now being established at selected airports to assess near-term, tactical initiatives and guide them through implementation.

The Office of System Capacity and Requirements has recently initiated an effort to identify, evaluate, and implement capacity improvements that are achievable in the near term and will provide more immediate relief for chronic delay-problem airports.

The first of these Tactical Initiative Teams completed a study at Los Angeles International Airport with a final report issued in September 1993. The team evaluated the impact on the crossfield taxiway system of proposed new gates on the west side of Tom Bradley International Terminal immediately adjacent to the taxiway system. The study examined airport delays and their causes (with and without the expansion of the west side of the terminal) and evaluated the effect of adding additional crossfield taxiways to mitigate the delays caused by the expansion.

A study was recently initiated at New York's LaGuardia Airport to evaluate the impact of introducing the Boeing 777-200 folding-wing aircraft on airfield operations. In addition to evaluating the effects of the new aircraft on capacity and efficiency, the study will examine the effects on safety, operating minimums, air traffic control procedures, and airway facilities.

Tentative plans call for a study at Orlando International Airport to evaluate the effects of proposed crossfield taxiways on airfield operations and a second study at Los Angeles International Airport to assess the impact on airfield operations of proposed remote commuter aircraft aprons.

2.6 Terminal Airspace Studies

The Office of System Capacity and Requirements has been developing a program of airspace capacity design team studies of the terminal and en route airspace associated with delay-problem airports across the country.

When an Airport Capacity Design Team study is completed, an airport has a recommended plan of action to increase its capacity. This plan will do little good, however, if the airspace in the vicinity of the airport cannot handle the increase in traffic. For this reason, the Office of System Capacity and Requirements has been developing a program of airspace capacity design team studies of the terminal and en route airspace associated with delay-problem airports across the country. Generally, these studies are intended to follow Airport Capacity Design Team studies. The first of these Terminal Airspace Studies was recently completed at San Bernardino International Airport (the former Norton Air Force Base). This study evaluated the impact of introducing scheduled air carrier service at the recently opened San Bernardino International Airport on the surrounding airspace, particularly the interaction of operations there with existing operations at Ontario International Airport. Additional studies were recently initiated at Philadelphia International Airport, Salt Lake City International Airport, and Tampa International Airport and are tentatively planned at San Antonio International Airport.

2.7 Regional Capacity Design Teams

Regional Capacity Design Team studies will analyze all the major airports in a metropolitan or regional system and model them in the same terminal airspace environment.

Looking beyond the individual airport and its immediate airspace, the Office of System Capacity and Requirements is planning a series of Regional Capacity Design Team studies. These regional studies will analyze all the major airports in a metropolitan or regional system and model them in the same terminal airspace environment. This regional perspective will show how capacity-producing improvements at one airport will affect air traffic operations at the other airports, and within the associated airspace. The first of these regional studies is planned for the San Francisco Bay area.

2.8 Airport Capacity Design Team Updates

The present Airport Capacity Design Team effort began in 1985. Many of the capacity-producing recommendations made by these Airport Capacity Design Teams have been implemented or are scheduled for completion, others may need to be reevaluated, and still others may no longer be appropriate. For some airports, particularly those with studies completed in the 1980's, conditions may have changed to a considerable extent, and a comprehensive new Airport Capacity Design Team study may be needed to bring the airport up to date. For other airports, changes in one or more of the conditions at the airport may only require a more limited update. An Airport Capacity Design Team Update is underway at Seattle-Tacoma International Airport to evaluate the impact on airport operations of a proposed new dependent runway and to examine the interaction of operations on the new runway with existing operations at Boeing Field/King County International Airport. A second update was recently initiated at Hartsfield Atlanta International Airport.

For some airports and a comprehensive new Airport Capacity Design Team study may be needed to bring the airport up to date.

Chapter 3

New Instrument Approach Procedures

Although substantial increases in capacity are best achieved through the building of new airports and new runways at existing airports, large projects like these are only completed after a long-term process of planning and construction. In an effort to meet the increasing demands on the aviation system in the near-term, the FAA has initiated improvements in air traffic control procedures designed to increase utilization of multiple runways and provide additional capacity at existing airports, while maintaining or improving the current level of safety in aircraft operations.

In FY93, more than half of all delays were attributed to adverse weather conditions. These delays are in part the result of instrument approach procedures that are much more restrictive than the visual procedures in effect during better weather conditions. Much of this delay could be eliminated if the approach procedures used during instrument meteorological conditions (IMC) were closer to those observed during visual meteorological conditions (VMC).

During the past few years, the FAA has been developing new capacity-enhancing approach procedures. These are multiple approach procedures aimed at increasing the number of airports and runway combinations that can be used simultaneously, either independently or dependently, in less than visual approach conditions.[1] "Independent" procedures are so called because aircraft arriving along one flight path do not affect arrivals along another flight path. "Dependent" procedures place restrictions between two arrival streams of aircraft because their proximity to each other has the potential for some interference. The testing of these new procedures has been thorough, involving various validation methods, including real-time simulations and live demonstrations at selected airports.

In FY93, more than half of all delays were attributed to adverse weather conditions. Much of this delay could be eliminated if the approach procedures used during IMC were closer to those observed during VMC.

During the past few years, the FAA has been developing new capacity-enhancing approach procedures aimed at increasing the number of airports and runway combinations that can be used simultaneously in less than visual approach conditions.

As a result of these efforts, new technologies have been implemented and new national standards have been published that enable the use of these capacity-enhancing approach procedures.

1. In general, depending on the airport's aircraft mix, single-runway IFR approach procedures allow about 29 arrivals per hour. Hence, two simultaneous approach streams, when operating independently of each other, double arrival capacity to 57 per hour. Three streams would allow 86 hourly arrivals, and so on. Such procedures are called independent, because arriving aircraft in one stream do not interfere with arrivals in the other. Conversely, "dependent" procedures place restrictions between the aircraft streams, and, as a result, hourly capacity for dual dependent approaches is somewhere between 29 and 57 arrivals. In the case of dependent triple streams, the arrival capacity is somewhere between 57 and 86, depending on airport runway configuration.

As a result of these development efforts, new technologies have been implemented and new national standards have been published that enable the use of these capacity-enhancing approach procedures.

- Simultaneous (independent) parallel approaches using the Precision Runway Monitor (PRM) to runways separated by 3,400 to 4,300 feet — published November 1991.The first PRM was commissioned at Raleigh-Durham International Airport in June 1993.
- Improved dependent parallel approaches to runways separated by 2,500 to 4,299 feet that reduce the required diagonal separation from 2.0 to 1.5 nm — published June 1992.
- Reduced longitudinal separation on wet runways from 3 to 2.5 nm inside the final approach fix (FAF) — published June 1992.
- Dependent converging instrument approaches using the Converging Runway Display Aid (CRDA) — published November 1992. The ARTS IIIA CRDA software upgrade is available for installation.
- Use of Flight Management System (FMS) computers to transition aircraft from the en route phase of flight to existing charted visual flight procedures (CVFP) and instrument landing system (ILS) approaches — published December 1992.
- Simultaneous ILS and localizer directional aid (LDA) approaches — procedures implemented at San Francisco International Airport.

The following sections present a brief description of the most promising approach concepts currently under development, including their estimated benefits, supporting technology, and candidate airports that might benefit from the new procedures. The busiest 100 airports are listed in Table 3-7 (described in Section 3.10), together with the new procedures that each can potentially use. Site-specific analysis is needed to determine which procedures are most beneficial to each airport.

3.1 Independent Parallel Approaches Using the Precision Runway Monitor (PRM)

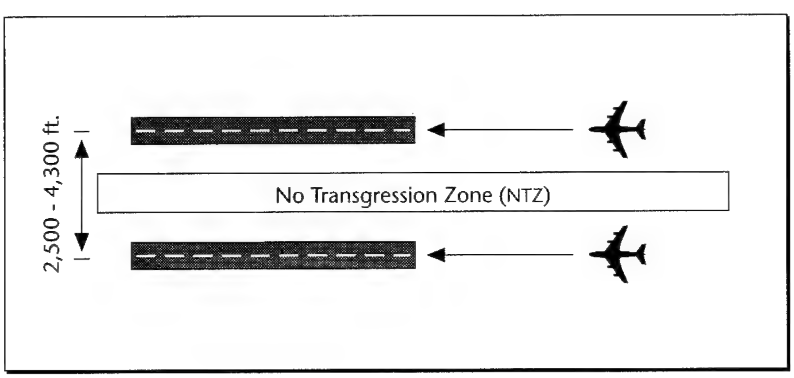
The FAA has authorized independent (simultaneous) instrument approaches to dual parallel runways since 1962, doubling the arrival capacity of an airport when visual approaches cannot be conducted. Initially, the spacing between the parallel runways was required to be at least 5,000 feet, but, in 1974, this was reduced to 4,300 feet. More than 15 U.S. airports are currently authorized to operate such independent parallel instrument approaches. A new national standard published in November 1991 authorized simultaneous (independent) parallel approaches to runways separated by 3,400 to 4,300 feet when the Precision Runway Monitor is in use.

The PRM system consists of an improved monopulse antenna system that provides high azimuth and range accuracy and higher data rates than the current terminal Airport Surveillance Radar (ASR) systems. The E-SCAN radar uses an electronic scanning antenna which is capable of updating an aircraft's position every half second. This update rate is an order of magnitude greater than the current ASR systems. The PRM processing system allows air traffic controllers to monitor the parallel approach courses on high-resolution color displays and generates controller alerts when an aircraft blunders off course.

Demonstrations of PRM technology were conducted at Raleigh-Durham International Airport in 1989 and 1990 using the E-SCAN radar. The first PRM system (E-SCAN) was commissioned at Raleigh Durham International Airport in June 1993. Additional systems are scheduled for delivery starting in the latter part of 1994.

It is anticipated that in 1995 simulations will be conducted at the FAA Technical Center to determine the minimum runway spacing, down to 2,500 feet, for independent parallel approaches using a PRM. Figure 3-1 illustrates these parallel instrument approaches using PRM. If successful, the average capacity gains expected from the use of these improved approaches would be 12-17 arrivals per hour.

Figure 3-1. Independent Parallel Instrument Approaches Using the Precision Runway Monitor (PRM)



3.2 Independent Parallel Approaches Using the Final Monitor Aid (FMA) with Current Radar Systems

The Final Monitor Aid is a high resolution color display that is equipped with the controller alert hardware and software that is used in the PRM system. The display includes alert algorithms that provide aircraft track predictors; a color change alert when an aircraft penetrates or is predicted to penetrate the no transgression zone (NTZ); a color change alert if the aircraft transponder becomes inoperative; and digital mapping.

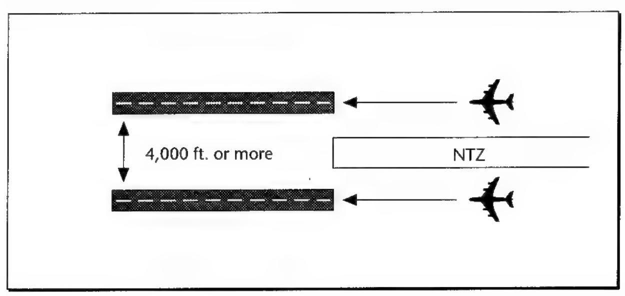
Studies revealed that using the FMA with current radar systems (4.8 second update rate) would improve the ability of controllers to detect blunders, thereby allowing a reduction in the minimum centerline spacing for independent parallel approaches. Real-time simulations, utilizing a larger "miss-distance" of 500 feet to allow for the possible effects of wake vortex, have been completed at the FAA Technical Center for dual and triple parallel runways spaced 4,300 feet apart. Data from these simulations are being analyzed, and, if the results are favorable, procedures will be published in 1994. Further simulations will be conducted for parallel runways spaced 4,000 feet apart. Figure 3-2 illustrates parallel instrument approaches using the FMA. Table 3-1 lists airports that have, or plan to have, parallel runways separated by 4,000 feet or more and indicates the average capacity gains expected from these improved approaches.

Table 3-1. Candidate Airports for Independent Parallel Approaches Using the Final Monitor Aid (FMA)

Candidates Among Top 100 Airports Average Capacity Gain 12-17 Arrivals/Hour		
Denver (DEN)*	Little Rock	Orlando
Detroit	Memphis	Phoenix
Grand Rapids	Nashville	Pittsburgh

* The new Denver International Airport.

Figure 3-2. Parallel Instrument Approaches Using the Final Monitor Aid (FMA)



3.3 Independent Parallel Approaches to Triple and Quadruple Runways Using Current Radar Systems

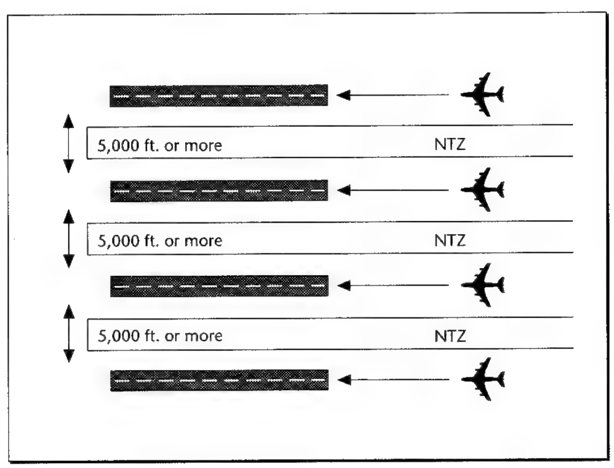
Several airports, including Dallas-Fort Worth, Orlando, and Pittsburgh, are planning on building parallel runways that will give them the capability to conduct triple and quadruple independent parallel approaches. This could result in as much as a 50 percent increase in arrival capacity for triple parallel arrivals and a 100 percent increase for quadruple arrivals.

Procedures allowing triple independent approaches to parallel runways separated by 5,000 feet at airports with field elevations of less than 1,000 feet with current radar systems were published in May 1993. Simulations for development of procedures for quadruple approaches are tentatively planned for 1995. Figure 3-3 illustrates triple and quadruple parallel approaches. Additional simulations will be conducted to determine the minimum runway spacing (less than 5,000 feet) for independent parallel approaches to triple and quadruple runways. Table 3-2 lists airports that have or plan to have parallel runways separated by 2,500 to 4,300 feet and indicates the average capacity gains expected from these improved approaches.

Table 3-2. Candidate Airports for Independent Parallel Approaches to Triple and Quadruple Runways

Candidates Among Top 100 Airports Average Capacity Gain 30 Arrivals/Hour
Dallas-Ft. Worth Denver (DEN)* Orlando Pittsburgh
* The new Denver International Airport.

Figure 3-3. Triple and Quadruple Parallel Approaches



3.4 Simultaneous Operations on Wet Intersecting Runways

Currently, simultaneous operations on intersecting runways require that the runways be dry. Over the past several years, demonstrations have been conducted at various airports using simultaneous operations on wet runways. Due to the success of these demonstrations, the FAA has initiated action to establish a national standard for allowing simultaneous operations on intersecting wet runways.

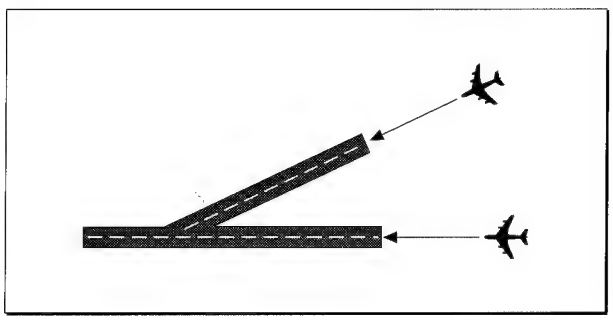
Of the top 100 airports, 60 currently conduct simultaneous operations on intersecting runways. Demonstrations have been ongoing at Boston Logan, Greater Pittsburgh, and Chicago O'Hare. Demonstrations are planned at New York's Kennedy, Philadelphia, and Miami International Airports. At O'Hare, increases of up to 25 percent have been experienced during wet runway operations.

An FAA team is in the process of formalizing procedures for these types of operations so that a national standard for simultaneous operations on wet intersecting runways can be established. The target date for implementation is the last quarter of FY94. Figure 3-4 illustrates simultaneous operations on wet intersecting runways. Table 3-3 lists airports that are candidates to conduct simultaneous operations on wet intersecting runways.

Table 3-3. Candidate Airports for Simultaneous Operations on Wet Intersecting Runways

Candidates Among Top 100 Airports Top 13 Candidate Airports		
Boston	Maimi	Philadelphia
Charlotte/Douglas	Minneapolis-St. Paul	Pittsburgh
Chicago O'Hare	New York (JFK)	San Francisco
Detroit	New York (LGA)	Washington National
	St. Louis	

Figure 3-4. Simultaneous Operations on Wet Intersecting Runways



3.5 Improved Operations on Parallel Runways Separated by Less Than 2,500 Feet

Current procedures consider parallel runways separated by less than 2,500 feet as a single runway during IFR operations. Simultaneous use of these runways for arrivals and departures is prohibited. This imposes a significant capacity penalty at numerous high-density airports. A recent analysis determined that airports such as Boston Logan International and Philadelphia International could achieve delay savings of over 80,000 hours per year if they were able to run dependent parallel arrivals. Table 3-4 lists airports that are candidates to conduct improved operations on parallel runways separated by less than 2,500 feet.

The FAA's Wake Vortex Program has been redefined to focus directly on the safety requirements for arrival and departure operations to parallel runways separated by less than 2,500 feet. It is anticipated that, among other things, the program will provide evidence supporting a reduction in the 2,500 foot requirement under most meteorological conditions.

Table 3-4. Candidate Airports for Improved Operations on Parallel Runways Separated by Less Than 2,500 Feet

Candidates Among Top 100 Airports		
Atlanta	Long Beach	Palm Beach
Boise	Los Angeles	Philadelphia
Boston	Memphis	Phoenix
Chicago Midway	Midland	Pittsburgh
Cincinnati	Milwaukee	Providence
Cleveland	Nashville	Raleigh-Durham
Dallas-Ft. Worth	New Orleans	Reno
Des Moines	New York (JFK)	San Antonio
Detroit	Newark	San Francisco
El Paso	Norfolk	San Jose
Houston Hobby	Oakland	Santa Ana
Houston Intercont'l	Oklahoma City	Seattle-Tacoma
Islip	Omaha	St. Louis
Knoxville	Ontario	Tucson
Las Vegas	Orlando	Washington Dulles

3.6 Dependent Approaches to Three Parallel Runways

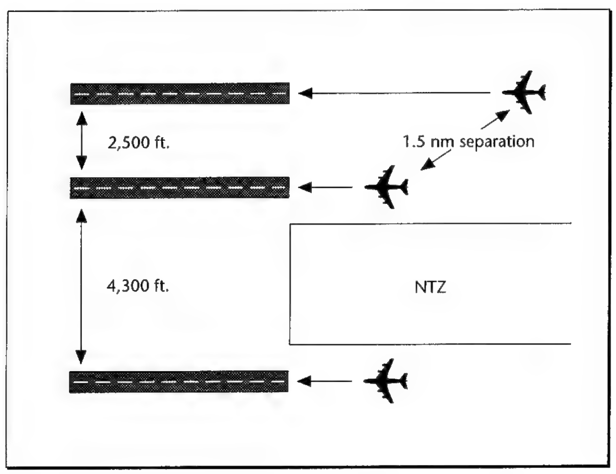
Procedures have been proposed that would allow approaches to three parallel runways when two may be operated independently of each other because of sufficient spacing and the third is dependent upon one of the others because of insufficient spacing. Currently, procedures allow simultaneous approaches to runways with centerlines spaced at least 3,400 feet apart, provided a Precision Runway Monitor (PRM) is available. However, those airports with spacing from 2,500 to 3,400 between one set of runways and 3,400 or 4,300 feet or more between the other set are limited to dual runway operations. Real-time simulations will be scheduled in the near future to test proposed procedures that will allow triple operations using dependent operations between one set of parallels and independent operations between the other set. Figure 3-5 illustrates independent and dependent parallel approaches, and Table 3-5 lists airports that are candidates for these improved approaches.

Table 3-5. Candidate Airports for Dependent Approaches to Three Parallel Runways

Candidates Among Top 100 Airports Average Capacity Gain 15 Arrivals/Hour		
Charlotte/Douglas	Detroit	Pittsburgh
Chicago O'Hare	Houston Intercont'l	Salt Lake City
Denver (DEN)*	Orlando	Washington Dulles

* The new Denver International Airport.

Figure 3-5. Independent and Dependent Parallel Approaches



3.7 Simultaneous (Independent) Converging Instrument Approaches

Under VFR, it is common to use converging runways for independent streams of arriving aircraft. In 1986, the FAA established a procedure for conducting independent instrument approaches to converging runways under instrument meteorological conditions (IMC). The procedure uses non-overlapping Terminal Instrument Procedures (TERPS) obstacle-clearance surfaces as a means of separation for aircraft executing simultaneous missed approaches. It assumes that each of the aircraft executing a turning missed approach can keep its course within the limits of its respective TERPS obstacle-free surface. The procedure also requires a 3 nm separation between the missed approach points (MAPs) on each approach. "TERPS+3" (as this procedure is often called) requires no dependency between the two aircraft on the converging approaches.

However, in order to keep the two MAPs 3 nm apart and ensure the TERPS surfaces do not overlap, the MAPs have to be moved back, away from the runway thresholds. This increases the separation between the TERPS surfaces and results in higher decision heights. Many runway configurations require decision heights greater than 700 feet in order to satisfy the TERPS+3 criteria. This restricts the application of the procedure to operations close to the boundary between VFR and IFR and limits the number of airports that could benefit from the procedure. The procedure cannot be used if the converging runways intersect; unless controllers can establish visual separation, and the ceiling and visibility are at or above 700 feet and 2 statute miles (sm).

In an effort to refine the independent converging approach procedures, a multi-disciplined work group, the Converging Approach Standards Technical Working Group (CASTWG), has been formed. This working group is analyzing various concepts which would result in lower approach of minimums.

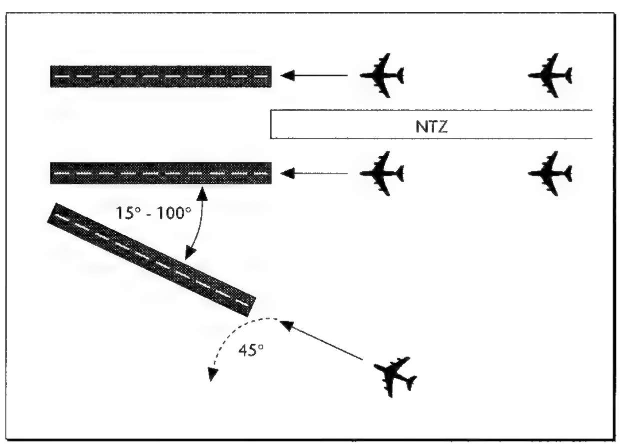
Data is being collected using various types of flight simulators to establish and/or validate required TERPS surfaces. Following the data collection and analysis, real-time simulations with controller and pilot participation may be conducted using radar laboratory and flight simulator demonstrations for further validation. Preliminary analysis indicates that several high-density airports will benefit from this refined independent converging instrument approach procedure. Figure 3-6 illustrates triple approaches, with dual parallels and one converging. Table 3-6 lists airports that are candidates to conduct these independent converging approaches and indicates the average capacity gains expected from these improved approaches.

Table 3-6. Candidate Airports for Independent Converging Approaches

Candidates Among Top 100 Airports Average Capacity Gain 30 Arrivals/Hour		
Baltimore	Houston Intercont'l	Oakland
Boston	Indianapolis	Omaha
Charlotte	Jacksonville	Philadlephia
Chicago Midway	Kansas City	Pittsburgh
Chicago O'Hare	Louisville	Portland
Cincinnati	Miami	Providence
Dallas-Ft. Worth	Milwaukee	Rochester
Dayton	Minneapolis	San Antonio
Denver (DEN)*	Nashville	San Francisco
Detroit	New York (JFK)	St. Louis
Ft. Lauderdale	New York (LGA)	Washington Dulles
Honolulu	New Orleans	Windsor Locks
Houston Hobby	Newark	

* The new Denver International Airport.

Figure 3-6. Triple Approaches: Dual Parallels and One Converging



3.8 Dependent Converging Instrument Approaches

Typically, independent converging IFR approaches using the TERPS+3 criteria are feasible only when ceilings are above 700 feet, depending upon runway geometry. As an alternative precision approach procedure, dependent IFR operations can be conducted to much lower minimums, usually down to Category I, thus expanding the period of time during which the runways can be used. However, to conduct these dependent operations efficiently, controllers need an automated method for ensuring that the aircraft on the different approaches remain safely separated. Without such a method, the separation of aircraft would be so large that little capacity would be gained.

A program was conducted at St. Louis (STL) to evaluate dependent operations using a controller automation aid called the Converging Runway Display Aid (CRDA) (also called ghosting or mirror imaging) to maintain aircraft stagger on approach. The CRDA displays an aircraft at its actual location and simultaneously displays its image at another location on the controllers scope to assist the controller in assessing the relative positions of aircraft that are on different approach paths. Results at St. Louis have shown an increase in arrival rates from 36 arrivals per hour to 48 arrivals per hour. National standards for this procedure were published in November 1992. The CRDA function is implemented in version A3.05 of the ARTS IIIA system.

The CRDA may also have other applications (see Section 5.2.1.1). For example, it could be used at airports with intersecting runways that have insufficient length to allow hold-short operations. Insufficient runway length between the threshold and the intersection with another runway can be ignored if arrivals are staggered such that one is clear of the intersection before the other crosses its respective threshold.

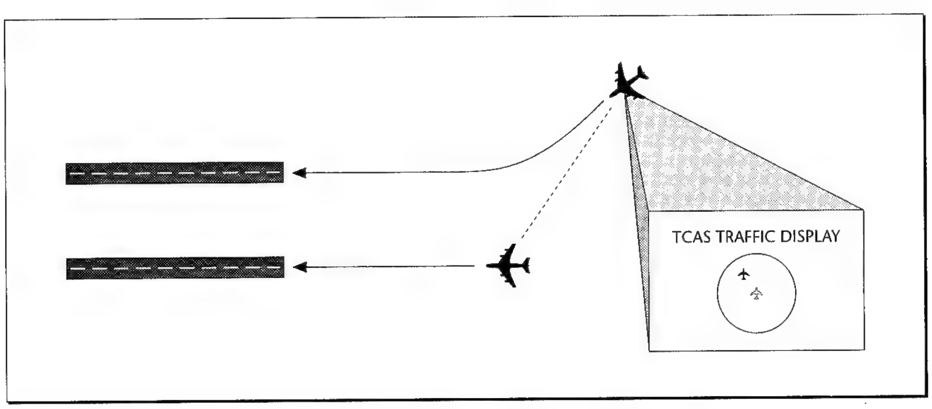
3.9 Traffic Alert and Collision Avoidance System (TCAS)/ Cockpit Display of Traffic Information (CDTI) for Separation Assistance

The cockpit display of traffic information associated with the Traffic Alert and Collision Avoidance System can provide the mechanism for flight crews to assist air traffic controllers in reducing the spacing tolerances that are maintained between aircraft for many phases of flight. Figure 3-7 illustrates one example of this use of TCAS/CDTI. The use of this information should result in capacity improvements beyond those which are available using radar and voice communications only.

A TCAS/CDTI feasibility study was published in April 1991. From that study, efforts are moving forward to conduct concept and interactive simulations that will eventually lead to refined ATC procedures. Data and information gathering is underway and preliminary concept simulations are being devised for testing in an integrated laboratory environment. Further, the use of full-motion simulators will evaluate the validity of proposed TCAS/CDTI applications in enhancing efficiency and capacity.

Initial emphasis has been on the use of TCAS/CDTI to support oceanic climbs and descents. In this application, the TCAS traffic display is used to determine a minimum safe distance when one aircraft wants to climb or descend through the altitude of another aircraft. Air traffic control then uses the information provided to them by the flight crew to issue an appropriate clearance. The inaugural validation flight for this procedure occurred in April 1994 over the Pacific Ocean. Further applications that take advantage of the TCAS capabilities are being explored to improve operational efficiency.

Figure 3-7. TCAS/CDTI for Separation Assistance



3.10 Approach Procedure Applicability at the Top 100 Airports

Table 3-7 shows the applicability of current and proposed procedures for the top 100 airports. The first column shows the current best hourly arrival capacity and the approach procedure utilized to achieve that capacity. The following columns show which of the proposed procedures discussed in the previous sections are applicable. It is important to bear in mind that this table is based on runway approach diagrams; factors such as noise, obstructions, and community concerns were not considered. Some airports may not be using their "current best" approach procedures. In addition, the actual aircraft fleet mix at each airport was not used; the capacity figures are numbers which are reasonable approximations of real capacity, used for comparison only. The objective of the table is to provide initial information on the applicability of approach procedures being developed by the FAA.

An asterisk (*) indicates that the proposed approach procedure in the column in question is applicable at a given airport, however, it also means that either the current best procedure, or another proposed approach procedure (under new rules), provides equal or better arrival capacity. A "p" indicates that the approach procedure may be applicable if and when proposed construction/extension plans actually take place. Some of this construction is in progress, and some is only at the proposal stage. A blank space indicates either that the runways do not support the proposed procedure, it is a borderline application, or there is not enough information to determine applicability. Finally, in order to highlight new approach procedures that would provide better capacity than any other procedures (current or proposed), an asterisk was replaced by a capacity number wherever the new procedure can provide higher capacity than any other. The number indicates the hourly arrival capacity of the procedure in question. It is easy to identify the most beneficial improvement by looking at the "New Approach Procedure" section in each row.

Table 3-7. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[2]

Airport	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[3]	New IFR Approach Procedures Depen. Parallel	Indepen. Parallel	CRDA	TERPS+3	Triples
Agana (Guam)	NGM	29 (S)					
Albany	ALB	29 (S)			34		
Albuquerque	ABQ	29 (S)			*	57	
Anchorage	ANC	29 (S)				57	
Atlanta	ATL	57 (IP)					86p
Austin (new airport)	BSM	57 (IP)					
Baltimore	BWI	29 (S)		57p	*	*p	
Birmingham	BHM	29 (S)			34sh		
Boise	BOI	29 (S)					
Boston	BOS	29 (S)	*		*	57	
Buffalo	BUF	29 (S)			34sh		
Burbank	BUR	29 (S)			34		
Charleston	CHS	29 (S)			34		
Charlotte	CLT	57 (IP)			*	*	86p
Charlotte Amalie	STT	29 (S)					
Chicago	MDW	29 (S)			34sh		
Chicago	ORD	57 (IP)			*	*	86p
Cincinnati	CVG	57 (IP)			*		
Cleveland	CLE	29 (S)			*	57p	
Colorado Springs	COS	57 (IP)			*	57	
Columbus	CMH	42 (DP)		57p		*sh	
Dallas	DAL	42 (DP)		57	*		
Dallas-Fort Worth	DFW	57 (IP, IC)				*	86p
Dane County	MSN	29 (S)			*sh		
Dayton	DAY	57 (IP)			*	*	
Denver (new airport)	DEN	57 (IP)					86
Des Moines	DSM	29 (S)			34		
Detroit	DTW	57 (IP)			*		71p
El Paso	ELP	29 (S)	*sh			57	
Fort Lauderdale	FLL	42 (DP)		57	*		
Fort Myers	RSW	29 (S)		57p			

Table 3-7. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[2]

Airport	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[3]	New IFR Approach Procedures Depen. Parallel	Indepen. Parallel	CRDA	TERPS+3	Triples
Grand Rapids	GRR	29 (S)		57p	*p	*p	
Greensboro	GSO	29 (S)		57p	*		
Greer	GSP	29 (S)		57p			
Harrisburg	MDT	29 (S)					
Hilo	ITO	29 (S)			34sh		
Honolulu	HNL	57 (IP)			*	*	
Houston Hobby	HOU	29 (S)			34		
Houston Intercont'l	IAH	57 (IP)				*	86p
Indianapolis	IND	42 (DP)		57p	*		
Islip	ISP	29 (S)			34sh		
Jacksonville	JAX	29 (S)		*p		57	
Kahului	OGG	29 (S)			34		
Kailua-Kona	KOA	29 (S)					
Kansas City	MCI	29 (S)		*p		57	
Knoxville	TYS	29 (S)	42				
Las Vegas	LAS	29 (S)			*	57p	
Lihue	LIH	29 (S)			*	57	
Little Rock	LIT	57 (IP)				*sh	
Los Angeles	LAX	57 (IP)					
Louisville	SDF	29 (S)		57p	*		
Lubbock	LBB	29 (S)			34		
Memphis	MEM	42 (DP)		*	*	57	
Miami	MIA	57 (IP)			*	*	
Midland	MAF	29 (S)	*		*	57sh	
Milwaukee	MKE	29 (S)	*	*p	*	57sh	
Minneapolis-St. Paul	MSP	42 (DP)		57	*		
Nashville	BNA	57 (IP)	*		*	57	
New Orleans	MSY	29 (S)		*p		57	
New York Kennedy	JFK	57 (IP)			*	*	
New York La Guardia	LGA	29 (S)			34		
Newark	EWR	29 (S)			*	57	

Table 3-7. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[2]

Airport	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[3]	New IFR Approach Procedures				
			Depen. Parallel	Indepen. Parallel	CRDA	TERPS+3	Triples
Norfolk	ORF	29 (S)			34sh		
Oakland	OAK	29 (S)	*			57	
Oklahoma City	OKC	57 (IP)			*	*	
Omaha	OMA	29 (S)	42sh		*		
Ontario	ONT	29 (S)					
Orlando	MCO	57 (IP)					86p
Philadelphia	PHL	57 (IC)		*p	*	*sh	
Phoenix	PHX	42 (DP)		57			
Pittsburgh	PIT	57 (IP)			*		71p
Portland, OR	PDX	42 (DP)		57	*	*	
Portland, ME	PWM	29 (S)			34sh		
Providence	PVD	29 (S)	42		*		
Raleigh-Durham	RDU	42 (DP)		*	*sh		71p
Reno	RNO	29 (S)			34		
Richmond	RIC	29 (S)			*sh	57	
Rochester	ROC	29 (S)			*sh	57sh	
Sacramento	SMF	57 (IP)					
Saipan	GSN	29 (S)					
Salt Lake City	SLC	42 (DP)		*		*	71p
San Antonio	SAT	29 (S)		*p	*	57	
San Diego	SAN	29 (S)			34sh		
San Francisco	SFO	29 (S)			34		
San Jose	SJC	29 (S)					
San Juan	SJU	29 (S)				57	
Santa Ana	SNA	29 (S)					
Sarasota-Bradenton	SRQ	29 (S)			34sh		
Seattle-Tacoma	SEA	29 (S)	42p				
Spokane	GEG	29 (S)		57p	*	*p	
St. Louis	STL	29 (S)	*	*p	*	57	
Syracuse	SYR	29 (S)		57p	*		
Tampa	TPA	57 (IP)			*	*	71p

Table 3-7. Potential Siting of New IFR Approach Procedures and Their Associated IFR Arrival Capacity[2]

Airport	Airport Code	Current Best IFR Arrival Capacity (App Procedure)[3]	New IFR Approach Procedures				
			Depen. Parallel	Indepen. Parallel	CRDA	TERPS+3	Triples
Tucson	TUS	29 (S)			*	57	
Tulsa	TUL	57 (IP)			*		86p
Washington National	DCA	29 (S)			34		
Washington Dulles	IAD	57 (IP, IC)				*	86p
West Palm Beach	PBI	29 (S)			34		
Wichita	ICT	57 (IP)			*	*	
Windsor Locks	BDL	29 (S)			34		

2. Generic (not airport-specific) capacities are used here to provide a basis of comparison only. These capacities, derived through the FAA Airfield Capacity Model, use a standard aircraft mix. Generally, runways not suitable for commercial operations were not considered. Also, factors such as winds and noise constraints are not taken into account.
3. Current Best Approach Abbreviations:

   DC - Dependent Converging Instrument Approaches

   DP - Dependent Parallel Runways

   IC - Independent Converging Runways

   IP - Independent Parallel Runways

   S - Single Runway

   - An asterisk (*) indicated proposed new approach procedures applicable at the airport in question; however, it also means that either the current best procedure, or another proposed approach procedure (under new rules), provides equal or better arrival capacity.
   - A number indicates that the hourly arrival capacity provided by a new approach procedure, when such capacity is larger than the one provided by other procedures (current or new), applicable at the airport in question.
   - A "p" indicates that the approach procedure will be applicable if and when planned runway construction/extensions take place at the airport in question.
   - An "sh" indicates that the approach procedure is applicable but that one of the runways is short (runway length less than 6,000 feet).

Chapter 4

Airspace Development

Efforts to expand airport capacity or implement improved instrument approach procedures will not be completely effective unless the terminal and en route airspace can handle the increased traffic. Airspace capacity design serves to emphasize the "system" nature of the delay problem and the need for an integrated approach that coordinates the development of capacity-producing alternatives. Airport improvements, enhanced air traffic control procedures, and improvements in terminal and en route airspace are frequently interrelated—changes in one require changes in the others before all of the potential capacity benefits are realized.

Airspace capacity design serves to emphasize the "system" nature of the delay problem and the need for an integrated approach that coordinates the development of capacity-producing alternatives.

Airspace Capacity Studies are a joint effort among the Office of System Capacity and Requirements, Air Traffic, and Regional Headquarters.

12 Airspace Capacity Studies have been completed, and 5 are currently in progress.

Airspace Capacity Studies are one of several programs underway to improve the efficiency of the airspace system. In a joint effort among the Office of System Capacity and Requirements, Air Traffic, Regional Headquarters, and a contractor that conducts the simulation modeling, 12 Airspace Capacity Studies have been completed, and 5 are currently in progress. Air Traffic, normally at the Regional level, develops the alternatives that will be tested in the simulation runs, and the proposed alternatives are generally examined in an ARTCC-wide context. Where possible, these studies reflect community involvement and FAA's responsiveness to community-developed alternatives.

A variety of computer models have been used to analyze a broad spectrum of capacity solutions. Since 1986, the Office of System Capacity and Requirements has been applying SIMMOD, the FAA's Airport and Airspace Simulation Model, to large scale airspace redesign issues. The first such project was an analysis of the Boston ARTCC in support of the expansion of that facility's airspace. Similar studies were initiated at the Los Angeles, Fort Worth, and Chicago ARTCCs, studying issues as diverse as resectorization, special use airspace restrictions, new routings, complete airspace redesign, and new runway construction. Computer modeling has been used to quantify delay, travel time, capacity, sector loading, and aircraft operating cost impacts of the proposed solutions.

Significant solutions to capacity and delay problems have been identified through airspace design. At Dallas-Ft. Worth, for example, effects of the Metroplex plan were studied both with and without new runway construction. Results indicated

an immediate savings from airspace changes alone. The airspace design projects completed to date have identified tens of millions of dollars in delay savings, and the vast majority of the airspace improvements identified in these studies either have been or are being implemented.

Table 4-1 summarizes the completed airspace studies by listing the generalized categories of the various alternatives studied. The majority of the studies considered new arrival and departure routes, modifications to ARTCC traffic, and redefinition of TRACON boundaries among their alternatives. Two studies, at Denver and Houston-Austin, analyzed a new airport with its associated airspace, while three studies, at Kansas City, Dallas-Ft. Worth, and Chicago, analyzed new runways at existing airports. Four of the studies, Houston-Austin, Oakland, Dallas-Ft. Worth, and Los Angeles, modeled military traffic, restricted airspace, special use airspace, or the interactions of a military airfield with the civilian airport.

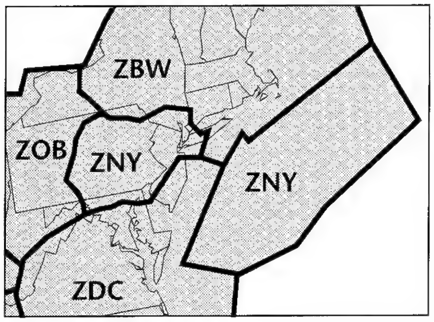
Table 4-1. Summary of Airspace Improvement Alternatives Analyzed.

Studied Alternatives / Airspace Regions	Chicago	Dallas-Ft. Worth	Denver	Expanded East Coast Plan	Houston-Austin	Kansas City	Los Angeles	Oakland	New York	Jacksonville	Atlanta	Miami
Relocating arrival fixes	√	√				√					√	
New arrival routes		√	√	√	√	√		√	√	√	√	√
New departure routes	√		√	√	√	√	√	√	√	√	√	√
Modifications to ARTCC traffic		√		√	√	√	√	√	√	√	√	
New airport			√		√							
Hub/non-hub alternatives					√							
Change in metering restrictions	√			√				√				√
Redifining TRACON boundaries		√		√	√		√	√			√	
Redifining sector ceilngs									√	√	√	
Resectorization									√	√	√	√
Military traffic considered		√			√		√	√				
New runways at existing airports	√	√				√						
Specific modeling of 2 or more airports for interactions analysis	√	√				√			√	√	√	√

The FAA plans to institutionalize these airspace modeling activities by expanding the capability of its Technical Center in Atlantic City, NJ. Under the direction of the Office of System Capacity and Requirements (ASC), the Technical Center, and soon the National Simulation Capability (see Section 5.5.1), will provide the FAA with the resources to conduct studies using a variety of models.

What follows are excerpts from the four airspace studies that were completed in the last year. The New York and Jacksonville Air Route Traffic Control Centers (ARTCCs) include a description of the alternatives analyzed and the results of the analysis. The final reports for the other two studies, Atlanta and Miami ARTCCs, were not available at publication time. Only a brief description of the alternatives is included here. Studies completed to date are summarized in Appendix G. It should be noted that these studies only considered the technical and operational feasibility of the proposed alternatives. Environmental, socioeconomic, and political issues were outside the scope of the studies and need to be addressed in future planning activities.

4.1 New York Airspace Capacity Project



The objective of the New York Airspace Capacity Project was to evaluate the delay and capacity impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations. The operational area of concern included operations within the New York Center and portions of Boston, Cleveland, and Washington Centers; and at Newark International, White Plains/Westchester County, Islip/Long Island MacArthur, John F. Kennedy International, LaGuardia, Philadelphia International, Newburgh/Stewart International, and Teterboro Airports.

To meet the objective of the New York Airspace Capacity Project, four major simulation analysis tasks were completed. The first task involved analyzing the impact of splitting Liberty Area's East Departure position into a high-low operation and rerouting certain traffic through the new low sector based on aircraft type and/or destination. The second task entailed evaluating air traffic operations under the proposed resectorization of New York Center Area D. The resectorization plan is aimed at relieving complexity and saturation problems associated with operations in New York Center's Sector 75 and involved the realignment of five en route sectors. The third task was an analysis to evaluate traffic loading impacts on the Stewart Area sector for three proposed ceiling realignment options. The fourth task involved an analysis of proposed new south arrival and south departure routings for Newburgh/Stewart International Airport to determine sector traffic loading impacts for potential future traffic growth.

4.1.1 Liberty East Reconfiguration and Rerouting

The first simulation analysis task involved evaluating the impacts of splitting New York TRACON Liberty Area's East Departure position into a high-low operation. The proposed operational alternative entails creating a new controller position and assigning all Liberty East airspace at or below 9,000 feet to the low operation. In addition to the traffic currently operating at 9,000 feet and below, additional flights departing to the northeast would also be rerouted to the new low sector based on destination and/or aircraft type.

Liberty East sector is situated just northeast of Newark International, JFK International, LaGuardia, and Teterboro Air-

ports, northwest of Islip/Long Island MacArthur Airport and directly above White Plains/ Westchester County Airport. The current Liberty East sector encompasses, at its maximum, a distance of 35 miles north to south and 45 miles east to west and abuts portions of New York and Boston Center en route airspace. The base of Liberty East airspace commences at 7,000 feet and attains its highest altitude at 17,000 feet. Considerable shelving exists at the lower altitudes where Liberty East interfaces with other New York TRACON sectors.

Proposed airspace changes to Liberty Area's East Departure sector entailed the splitting off of all existing Liberty East airspace at or below 9,000 feet. A new Liberty East low sector is created from the lower portions of the eastern half of the existing Liberty East sector. The remaining Liberty East airspace (referred to as the new Liberty East high sector) is comprised of the Liberty East airspace at and above 10,000 feet. It was assumed that departures which currently transit Liberty East airspace at or below 9,000 feet would, under the reconfigured airspace, be routed at the same existing altitudes, and, therefore, be worked by the new Liberty East low sector controller.

Ten operational scenarios were simulated for the Liberty East reconfiguration and rerouting analysis. Nine potential alternatives were simulated for comparison to the baseline "do nothing" case (Alternative 0). Alternative 1 entailed reconfiguration of Liberty East only, without rerouting of any traffic. For Liberty East Alternatives 2 through 9, various combinations of flights currently using altitudes at or above 10,000 feet (i.e., in the new Liberty East high sector) were rerouted to the new Liberty East low sector. Three distance ranges were used in each scenario as criteria for rerouting traffic from new Liberty East high sector to new Liberty East low sector.

Results of the analysis for Alternative 0, or the "do nothing" case, show that traffic is projected to increase 19 percent (98 aircraft) by the year 1997 and 34 percent (173 aircraft) for the year 2003. With current operational conditions requiring potential airspace realignment and rerouting of traffic for Liberty East sector, it is most likely that these future traffic increases projected for Liberty East will result in even greater workload problems and issues.

Alternative 1 considered reconfiguring Liberty East Departure sector into a high-low operation without rerouting any traffic. This alternative provided some degree of relief, but a further redistribution of traffic between new Liberty East high and new Liberty East low sectors is recommended if a more equitable balance between the sectors is to be achieved in both the near and future years. The shift in traffic flows between the

new sectors under Alternatives 2 and 4, when compared to Alternative 1 results, tends towards a more balanced distribution of traffic between the two new Liberty East sectors throughout the day. Liberty East departure flights destined for airports within the 126-175 nautical mile range of the New York area are pivotal in redistributing traffic from the new Liberty East high sector into the new Liberty low sector for purposes of balancing traffic loading. The remaining alternatives show even more improvement in reducing the percentage of time during the day that the sectors are saturated (the sector is considered saturated during a 15-minute period if the controller is continuously working the maximum number of aircraft).

4.1.2 Resectorization of New York ARTCC (ZNY) Area D

The second task evaluated air traffic operations under the proposed resectorization of New York Center Area D (see Figure 4-1). The resectorization plan is aimed at relieving complexity and saturation problems associated with operations in ZNY Area D Sector 75. To accomplish the proposed operational changes, significant resectorization of Sector 75 and four other ZNY Area D sectors was necessary (Sectors 74, 91, 92, and 93). ZNY Sector 75 is the focal point of the New York Center Area D resectorization plan. ZNY Area D Sector 75 is located to the north of Sector 73 and directly abuts Cleveland Center airspace. Except for a small portion located in the northeast corner, Sector 75 commences at FL180 and extends up to FL600. The northeast portion of Sector 75 encompasses airspace from FL180 up to FL230. Sector 75 lateral airspace varies in distance from 40 miles north to south to over 100 miles east to west.

Resectorization of Sector 75 will require a slight extension of the farthest northwest corner of Sector 75 airspace. The only other airspace modification to Sector 75 requires raising the floor from FL180 to FL220. Adjacent Sectors 74 and 93 will acquire the airspace between FL180 and FL220. With the realignment of Sector 75, Newark International and LaGuardia arrivals will be descended to FL220 earlier for hand off to Sector 74. In addition, all Baltimore traffic will be removed from Sector 75 to be worked by Sector 93. Elmira, Binghamton, and Utica arrivals will also be removed from Sector 75 along with any overflight traffic below FL220. Philadelphia International, Allentown, Lancaster, and Harrisburg northbound departures will be assigned to Sector 74, thus bypassing Sector 75.

Results of the analysis show that on the average day, the resectorization of ZNY Area D would result in daily delay savings amounting to 13, 35, and 122 hours per day for the 1991, 1997, and 2003 demand levels, respectively. These delay savings equate to an annual aircraft operating cost savings of $7.6 million, $20.4 million, and $71.2 million, per respective year.

The primary goal of the resectorization of ZNY Area D is to reduce complexity and saturation within Sector 75 by reducing the level of traffic worked by the ZNY Sector 75 controllers during busy periods. For the baseline (1991) year, there was a 17 percent decline in Sector 75 daily operations. The reduction would be 18 percent in 1997 and 18 percent in 2003. By resectorizing ZNY Area D, Sector 75 would realize substantial reduction in 15-minute sector occupancy averages throughout the majority of the day. These declines in sector occupancy averages result from the traffic rerouted from Sector 75 into Sectors 74 and 93, plus the reduction in the time aircraft are worked by Sector 75 due to Sectors 74 and 93 assuming portions of Sector 75 airspace.

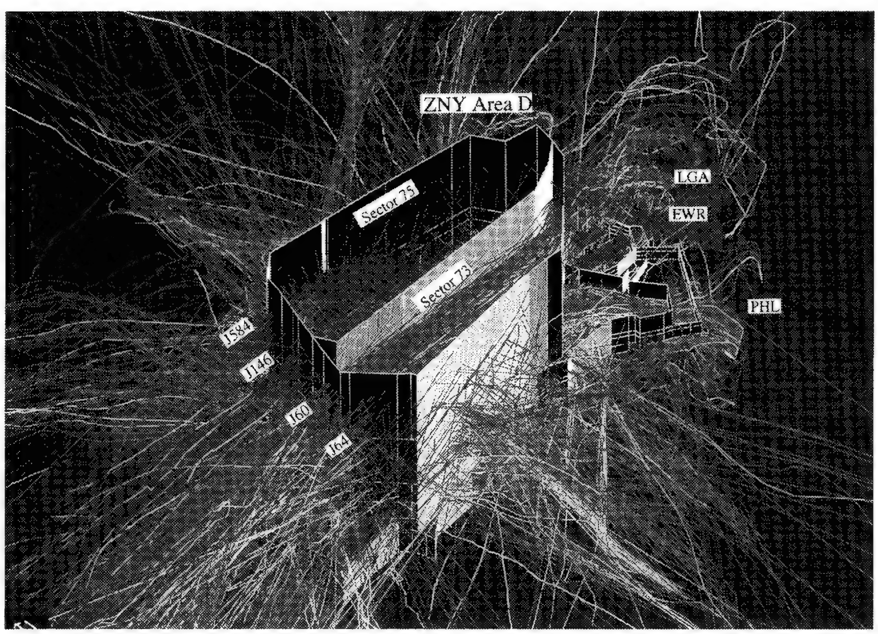


Figure 4-1. Northeast oblique view of radar tracks traversing New York Center's Area D in a single day.

4.1.3 Stewart Area Airspace Redesign

The third simulation analysis evaluated air traffic operations under the proposed raising of the ceiling of the southern portion of the New York TRACON Stewart Area. The proposed alternatives consist of Stewart Area ceiling altitude changes of 10,000, 14,000, and 17,000 feet. Under these three ceiling options, traffic loading is evaluated to determine the additional traffic which Stewart Area would acquire if the new ceiling altitudes were implemented.

There are eleven airports located in the Stewart Area with Newburgh/Stewart International (SWF) and Dutchess County (POU) accounting for the majority of traffic. Newburgh/ Stewart International Airport is situated 40-50 miles to the north of Newark International, John F. Kennedy International, and LaGuardia Airports. Stewart Area encompasses, at its maximum, a distance of 50 miles north to south and 85 miles east to west. Current Stewart Area ceilings range between 4,000 to 6,000 feet with the northwestern portions of Stewart Area overlying areas of high terrain. Stewart Area airspace underlies portions of both New York and Boston Center en route airspace.

By raising the southern portion of the Stewart Area to 10,000 feet, Stewart Area would acquire 329 additional flights over the busiest periods of the day. This increase in traffic is over a 200 percent increase above current traffic loading in the Stewart Area. A ceiling realignment to 14,000 feet for Stewart Area's southern portion would result in Stewart Area acquiring an additional 113 flights above the number attained with the ceiling realignment at 10,000 feet. Total traffic for Stewart Area with the 14,000 foot ceiling realignment would increase to 593 flights during the busiest periods, an increase over the current traffic level of nearly 400 percent. A 17,000 foot ceiling in the Stewart Area's southern portion would further increase traffic counts for Stewart Area during the busiest periods to a total of 630 flights.

4.1.4 Potential Traffic Growth at Newburgh/Stewart International Airport (SWF)

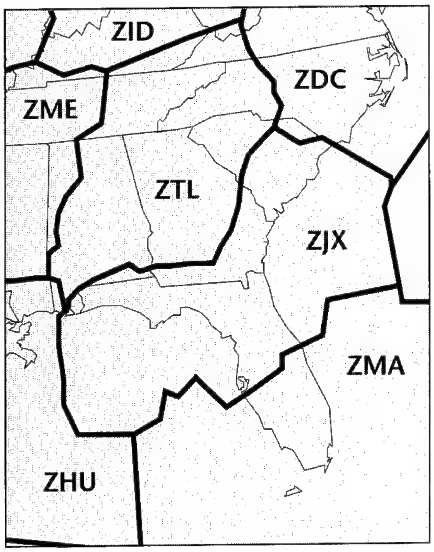
The fourth task analyzed proposed new arrival and departure routings to the south of Newburgh/Stewart International Airport to determine traffic loading implications for potential future traffic growth at SWF. Simulation results were analyzed to evaluate the impact that additional Newburgh/Stewart International departure flights would have on ZNY Sectors 39 and 10, and the impact that additional arrival flights to Newburgh/Stewart International Airport would have on the new proposed Liberty East high sector.

For the Liberty East high sector scenario, it was assumed that the Liberty East Departure sector is split into a new high-low operation and that the Stewart Area southeast ceiling is raised to an altitude allowing new Liberty East high sector to hand off directly to Stewart Area. For the potential Stewart Area Airport growth scenarios, two traffic level increases were simulated for Newburgh/Stewart International Airport south departures and arrivals. The first traffic level increase (medium growth) consisted of 30 additional south arrivals and south departures at Newburgh/Stewart International Airport per day. The second traffic level increase (high growth) consisted of 60 additional south arrivals and departures per day.

ZNY Sectors 39 and 10 would be impacted by potential traffic growth at Newburgh/Stewart International Airport due to traffic utilizing a proposed new south departure route from SWF. Medium traffic growth could potentially impact early morning operations for both Sectors 39 and 10. Under high traffic growth levels at SWF, the early morning traffic flow increases become quite substantial and sustained in duration and would most likely result in workload issues for both Sectors 39 and 10.

The proposed new Liberty East high sector would also be impacted by potential traffic growth at Newburgh/Stewart International Airport due to traffic utilizing a proposed new south arrival route to SWF. The new Liberty East high sector would be slightly impacted during the morning period under medium traffic growth at SWF. Under the high traffic growth scenario, new Liberty East high sector would experience substantial and sustained increases in early morning as well as afternoon traffic flows, potentially resulting in workload considerations for new Liberty East high sector.

4.2 Jacksonville Airspace Capacity Project



The objective of the Jacksonville Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations at Jacksonville Center (ZJX), Orlando Approach Control, Tampa Approach Control, and Orlando International (MCO) and Tampa International (TPA) Airports. Measures that could increase capacity and reduce delays were considered solely on a technical basis. Environmental, economic, social, or political issues were beyond the scope of the study.

Five major simulation analysis tasks were completed. The first task involved analyzing the impact on Jacksonville Center traffic resulting from a proposed reconfiguration of the Palatka MOA Complex. The second task entailed an evaluation of the proposed implementation of a jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN). The third task was an evaluation of the impact of a similar proposed jet airway between St. Petersburg VORTAC (PIE) and a point 42 nautical miles (nm) west of Tallahassee VORTAC (TLH). The fourth task involved an analysis of the impact of raising the ceiling of Orlando Approach Control in conjunction with modifying arrival and departure routings. The fifth task entailed an evaluation of an alternative en route airspace design within Jacksonville Center.

4.2.1 The Proposed Palatka MOA/ATCAA Realignment

This first task analyzed a proposal to modify the lateral and vertical limits of the existing Palatka MOAs and redesignating the airspace above the proposed MOA expansion as ATC Assigned Airspace (ATCAA). In scenarios simulating the proposed Palatka MOA/ATCAA Complex, the existing Polatka MOAs were reconfigured to reflect airspace structures extending from 1200 feet AGL (above ground level) up to and including FL430. A substantial expansion of the lateral boundaries of the existing airspace was also required.

The proposed Palatka MOA/ATCAA Complex would require Jacksonville Center to release large portions of several low, high, and ultra-high sectors for special use operations during the hours of activation.

The impact of rerouting Jacksonville Center traffic currently overflying the proposed Palatka MOA/ATCAA results in

delay and travel time penalties. Delay time increases account for the majority of the total time penalty realized for the traffic demand schedules evaluated. In the baseline (1991) case, a total daily flight time penalty of 4.1 hours per day is realized with the annual cost penalty equating to $2.4 million. Annual cost penalties increase to $11.0 million and $120.6 million for the 1997 and 2003 traffic demand levels. This proposed alternative would substantially reduce airspace previously available for the vectoring of traffic to relieve congestion. Requiring traffic to be rerouted around the expanded Palatka MOA Complex, significantly reduces the flexibility of controllers to utilize vectors and/or direct routes to expedite traffic movement. Controllers currently use portions of the airspace to be included in the proposed Palatka MOA expansion for sequencing of Orlando Approach Control arrival and departure traffic and vectoring/direct routing of Jacksonville Center overflight traffic.

4.2.2 Rainbow Area Airway

The objective of the Rainbow Area Airway analysis was to evaluate the potential benefits that may be realized by establishing a jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN). The proposed airway would traverse airspace currently designated as special use airspace (SUA), impacting the area commonly known as the "Rainbow Area." In addition to acquiring portions of the Rainbow Area, other requirements necessary to establish the proposed airway would include: releasing all altitudes for the jet airway from special use; incorporating any remaining special use airspace FL180 and above west of the proposed airway boundary and J79; and releasing special use airspace below FL180 located just north of OMN to accommodate the descent and vectoring of arrival traffic into the Orlando terminal area. The proposed airway would require no change to the physical boundaries of any existing Jacksonville Center sector structures, but the usable airspace available for traffic movement within the impacted sectors would be increased. Rerouting of traffic through any new or additional sectors would not be required.

The implementation of a proposed jet airway between Charleston VORTAC (CHS) and Ormond Beach VORTAC (OMN) would reduce flight time and increase available airspace for improved flexibility and efficiency in the movement of air traffic. During Visual Meteorological Conditions (VMC), the proposed jet airway would result in daily travel time and delay savings totaling 1.7, 2.4, and 4.4 hours for the years 1991, 1997, and 2003, respectively. This delay savings would provide

$1.0 million, $1.4 million, and $2.6 million in cost savings per traffic demand year. Additional operating cost savings can be realized with the proposed airway during periods when thunderstorms preclude or reduce the availability of current routes. In a year where thunderstorm activity was to occur a total of 60 times, lasting an average duration of two hours, the aircraft operating cost savings realized by having the proposed airway available would total $13.8 million, $23.8 million, and $56.7 million in years 1991, 1997, and 2003, respectively.

4.2.3 Proposed ACMI/ Thunder Area Airway

The objective of the ACMI/Thunder Area Airway impact analysis was to evaluate the potential benefits that may be realized by establishing an airway between St. Petersburg VORTAC (PIE) and a point 42 nm west of Tallahassee VORTAC (TLH). The proposed airway would traverse portions of the special use airspace designated as the ACMI/Thunder Area. The analysis involves an evaluation of the potential benefits derived by overflight traffic from the implementation of the proposed airway.

The proposed airway would require no change to the physical boundaries of any existing Jacksonville Center sector structures, but the usable airspace available for traffic movement within the sectors with the proposed airway would be increased. Rerouting of traffic through any new or additional sectors would not be required.

The implementation of a jet airway between St. Petersburg VORTAC (PIE) and a point 42 nm west of Tallahassee VORTAC (TLH) would also increase the available airspace for improved movement of traffic within Jacksonville Center. During VMC, the proposed jet airway would result in daily travel time and delay savings totaling 1.6, 2.0, and 6.4 hours for the years 1991, 1997, and 2003, respectively. The delay savings would provide $1.0 million, $1.2 million, and $3.7 million in cost savings per traffic demand year.

The availability of the proposed jet airway (between PIE and a point 42 nm west of TLH) to traffic during periods of thunderstorm activity would also result in significant operating cost savings. For example, if yearly thunderstorm activity were to occur a total of 60 times, lasting an average duration of two hours, the aircraft operating cost savings realized by having the proposed airway available would total $2.1 million, $7.9 million, and $25.1 million in years 1991, 1997, and 2003, respectively.

4.2.4 Orlando Approach Control Airspace Modification

The fourth task was to analyze the impact of raising the ceiling of the current Orlando Approach Control airspace, in conjunction with modifying arrival and departure routings. This scenario was conducted to evaluate possible improvement of the traffic flow within Jacksonville Center. The proposed Orlando Approach Control reconfiguration raises the existing ceiling of the approach control from 12,000 to 14,000 feet, expanding terminal airspace in order to provide Jacksonville Center the capability to establish dual jet arrival routes and segregated jet and turboprop departure routes.

Orlando Approach Control currently provides air traffic services in the airspace up to 12,000 feet and out to distances of 50 nm from Orlando International Airport. Orlando Approach Control airspace is located in central Florida and is situated beneath the common boundary between Jacksonville and Miami Centers. The primary airports serviced by Orlando Approach Control include Orlando International (MCO), Orlando Executive (ORL), and Sanford/Central Florida Regional (SFB) Airports.

To raise the ceiling of Orlando Approach Control from 12,000 to 14,000 feet, airspace would have to be acquired from the Jacksonville Center low altitude sectors directly above the current approach control airspace. In conjunction with raising the ceiling, arrival and departure routes within Orlando Approach Control would also have to be modified.

The Orlando Approach Control Airspace modification option realized savings in daily delay and flight time during all three traffic demand levels. The improved efficiency of the en route system results from traffic entering and departing Orlando Approach Control airspace in a less restricted manner, and the utilization of the reduced separation standards available in the expanded terminal environment. Raising the Orlando Approach Control ceiling from 12,000 to 14,000 feet expands terminal airspace, providing the capability for Jacksonville Center to establish both, dual jet arrival routes and segregated jet and turboprop departure routes. The capability to use dual arrival and segregated departure routes under the proposed Orlando Approach Control airspace realignment would result in daily en route delay and travel time savings amounting to 3.5, 4.7, and 22.2 hours per day for the 1991, 1997, and 2003 traffic demand levels, respectively. The combined savings equate to an annual aircraft operating cost savings of $2.0 million, $2.7 million, and $13.0 million, per respective traffic demand year.

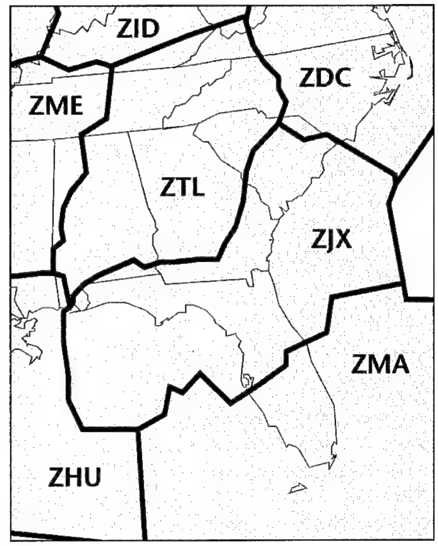
4.2.5 Jacksonville Center Proposed Airspace Redesign Alternative

The final analysis objective of the Jacksonville Airspace Capacity project was to assess the impact and potential benefits of a proposal to modify the floors and ceilings of special sectors within Jacksonville Center. The analysis of the Jacksonville Center Airspace Redesign alternative involved simulating en route airspace operations for existing and proposed sector configurations. Traffic demand levels for the baseline year (1991) and future projected traffic levels for years 1997 and 2003 were simulated.

The Jacksonville Center Airspace Redesign alternative would require airspace realignment for 27 of the 38 en route sectors. The majority of these airspace changes would involve floor and/or ceiling realignments. Four Jacksonville Center low altitude sectors would also require lateral boundary expansions in order to acquire airspace above adjacent approach controls. The proposed realignment of the designated Jacksonville Center sectors would have the effect of redistributing some existing traffic flows from one airspace structure to another. No rerouting of existing traffic flows was proposed.

Results from the simulation indicate that the benefits that may be gained by the realignment of the floors and/or ceilings of sectors within Jacksonville Center include a more balanced traffic distribution, improved intra-facility coordination, added flexibility for the handling of traffic during demand peaks, and improved efficiency in merging traffic.

4.3 Atlanta Center Airspace Capacity Project



The objective of the Atlanta Center Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations within Atlanta Center and at Charlotte (CLT), Raleigh-Durham (RDU), and Birmingham (BHM) Approach Controls, and Atlanta, Charlotte/Douglas, and Raleigh-Durham International Airports and Birmingham Airport.

Seven analysis tasks were studied to meet the objectives of the Atlanta Center Airspace Capacity Project. The final report for this project was not available at publication time. However, the analysis tasks are briefly described below.

The first task involved raising the ceiling at Raleigh Approach Control airspace from 10,000 to 12,000 feet. Potential benefits associated with realigning Raleigh Approach Control would be a more efficient traffic merging with Washington Center, a reduction in intra- and inter-facility coordination, an expansion of approach control airspace for more flexible handling of arrival and departure traffic, and relaxation of departure restrictions. Rerouting of existing traffic flows was not required under the Raleigh Approach Control ceiling realignment option. However, certain miles-in-trail and speed restrictions currently in effect were relaxed.

The second task involved raising the ceiling at Charlotte Approach Control from 12,000 to 14,000 feet, at Raleigh Approach Control from 10,000 to 14,000 feet, and those at Greensboro and Fayetteville Approach Controls from 10,000 to 12,000 feet. En route corridors were maintained from 11,000 feet and above across Fayetteville and Greensboro Approach Controls for BUZZY and MAJIC arrivals respectively. Rerouting of existing traffic flows was not required under the four ceilings realignment option. However, certain miles-in-trail and speed restrictions currently in effect were relaxed.

The third task analyzed the impact of moving the boundary of Washington Center to the west to assume full control of Raleigh Approach Control and portions of low, high, and ultra-high altitude sectors in Atlanta Center. Extensive routing and terminal airspace changes were also proposed to accommodate rotation of the Bedposts/Cornerposts within Raleigh Approach Control airspace. A second departure gate for Charlotte International Airport southbound jet traffic was also developed. Other related scenarios within the alternative evaluated several approach control ceiling realignments.

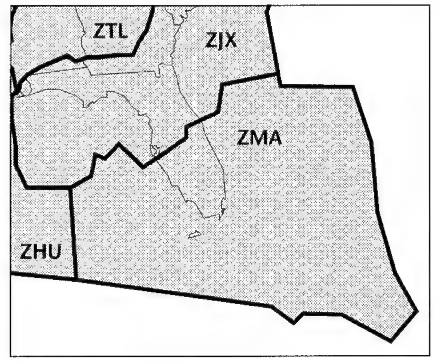
The fourth task involved analyzing the impact of moving the boundary of Atlanta Center to the east along a line crossing approximately over SBV, RDU, and FAY with Atlanta Center acquiring possibly the equivalent of three low altitude sectors from Washington Center. In this analysis, there was a redefinition of several en route sectors, establishment of new en route sectors, and extensive routing and terminal airspace changes to accommodate rotation of the Bedposts/Cornerposts within Raleigh Approach Control airspace. A second departure gate for Charlotte International Airport southbound jet traffic was also developed. Other related scenarios within this alternative evaluated several approach control ceiling realignments.

The fifth task analyzed the impact of extending the existing Jet Airway 209 and rerouting certain flights currently entering Atlanta Center Airspace between the Meridian (MAW) and Crestview (CEW) VORTACs. The proposed lengthening of J209 required adding a segment to the current airway beginning at Greenwood VORTAC (GRD) and extending southwest to the Columbus VORTAC (CSG). Traffic with specific destinations would be rerouted onto the proposed segment, at a point south of where current J209 traffic flow is merged. To facilitate the airway extension, a proposed modification to the current sectorization within the Atlanta Center high altitude structure, south of Atlanta VORTAC (ATL), was required.

The sixth task analyzed the impact of eliminating Atlanta Center's Birmingham Sector (12) by expanding Rome (01), West Departure (04), and Maxwell (14) sectors' boundaries to encompass airspace and associated traffic within the existing Birmingham Sector (12). The objective of this task was to determine the additional traffic which Rome (01), West Departure (04), and Maxwell (14) sectors would acquire under current and future traffic demand levels if Birmingham Sector (12) was eliminated.

The seventh task evaluated the impact of raising the ceiling of Birmingham Approach Control from 10,000 to 12,000 feet and modifying arrival and departure routings in order to establish Arrival and Departure Transition Areas (ATAs/DTAs).

4.4 Miami Center Airspace Capacity Project



The objective of the Miami Airspace Capacity Project was to evaluate the capacity and delay impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations within Miami Center, at Miami, Orlando, and Tampa Approach Controls, and Miami, Orlando, and Tampa International Airports.

Four analysis tasks were studied to meet the objectives of the Miami Center Airspace Capacity Project. The final report for this project was not available at publication time. However, the analysis tasks for this project will be briefly described below.

The first analysis task evaluated the impact of a proposed realignment of Miami Center Vero Beach (R3) and Melbourne (R4) Sectors to accommodate projected near term traffic growth at Fort Pierce/St. Lucie County International Airport (FPR). Currently, Vero Beach and Melbourne Sectors are split horizontally. The proposed realignment laterally realigns the existing airspace comprising R3/R4, thus establishing new Vero Beach (R3) and Melbourne (R4) Sectors and segregates VRB/FPR arrivals from VRB/FPR departures.

The second analysis task analyzed the impact of parallel airways through the Orlando corridor. The proposed westside airway would accommodate traffic flying over and west of IRQ (Colliers), whereas the eastside airway would accommodate the remaining J53 air traffic operating at or above FL330. The establishment of parallel airways would allow relaxation of current in-trail restrictions currently placed on Miami Center departures northbound to Jacksonville Center over ORL VORTAC.

The third analysis task evaluated a proposal to establish a new Miami Center Sector R59 by realigning current Miami Center Bimini High (R40) and Georgetown (R60) sectors. No rerouting of air traffic was required. The proposed Sector R59 would primarily accommodate overflight traffic at altitude operating between the mainland U.S. north of Miami Center, and the Caribbean or South America. The new realigned Bimini (R40) sector would still accommodate some north/south overflights as well as the majority of flights that comprise the traffic to and from the Bahamas and south Florida. The new realigned Georgetown (R60) would continue to handle north/south overflights with traffic between south Florida and the Caribbean or South America comprising the majority of the traffic.

The fourth analysis task analyzed the effect of establishing a new airway west of A509/A301 for southbound Miami Center traffic bound for Cuban airspace. Currently, northbound and southbound traffic are required to share A509/A301. The proposed new airway would provide separate routes for Miami area arrivals and departures to and from Cuban airspace.

4.5 Studies in Progress

Currently, the FAA Office of System Capacity and Requirements has the following airspace projects underway: the Los Angeles Regulatory Airspace Simplification Project.

The Los Angeles regulatory airspace simplification project does not, as currently envisioned, involve the use of SIMMOD. It will be a three-dimensional depiction of the regulatory and control airspace with the underlying geography and the actual radar track data interfaced. The objective is to determine whether there is regulated airspace that is not used by a significant number of IFR aircraft. If so, that airspace could then be released to allow less restricted VFR flights through the Los Angeles area. This project is being coordinated through the Western Pacific Region with the Southern California Airspace Users Group (SCAG). Any follow-on modeling analysis required will also be accommodated.

Chapter 5

Technology for Capacity Improvement

There are many technological initiatives underway which promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace. When considered individually, the primary focus of a large number of technologies and projects might be other than capacity enhancement, even so, these technologies are significant steps in the right direction. The impact of each initiative will be enhanced by an integrated approach to capacity improvement that results in effective coordination of the various programs. At a national level, this integration will be accomplished through the activities of the National Simulation Capability described in Section 5.5.1.

Section 5.1 covers technologies applicable to airport surface operations. Section 5.2 discusses programs that apply to the adjacent terminal airspace and directly support the approach procedure improvements discussed in Chapter 3. Section 5.3 discusses technologies applicable to the en route airspace, including oceanic airspace. Section 5.4 addresses capabilities that will support traffic flow managers, both national and local, in maintaining a planned, systematic flow of air traffic. Section 5.5 covers technologies and programs that support planning and integration of the above programs, as well as technologies that will make changes and improvements to the National Airspace System (NAS) easier and more efficient to implement.

The summaries included in this chapter are meant to be general descriptions of technologies and projects, currently underway or under development, which promise to increase system capacity. For a more detailed description of these and other technologies and projects, refer to Appendix H. Many of those projects are also listed in the FAA's R,E&D Plan.

There are many technological initiatives underway that promise to improve the capacity of an airport, its surrounding terminal airspace, and the en route airspace.

The impact of each initiative will be enhanced by an integrated approach to capacity improvement that results in effective coordination of the various programs. This integration will be accomplished through the activities of the National Simulation Capability.

5.1 Airport Surface Capacity Technology

Taxiway interference, separation at intersections, departure sequencing, and the like, all contribute to surface-related flight delays. The Airport Surface Traffic Automation System (ASTA) will provide automation designed to make ground operations safer and more efficient.

5.1.1 Airport Surface Traffic Automation Program

To increase aviation safety by reducing runway incursions and surface collisions in the airport movement area and to provide controllers with automated aids to reduce delays and improve the efficiency of surface movement.

The purpose of the ASTA program is to increase aviation safety by reducing runway incursions and surface collisions in the airport movement area and to provide controllers with automated aids to reduce delays and improve the efficiency of surface movement.

The ASTA program comprises five elements: a runway status light system, a surveillance data link, aural and visual warnings, data tags, and a traffic planner. The program will develop an enhanced surface safety system using the Airport Surface Detection Equipment (ASDE-3) primary ground sensor radar, Automated Radar Terminal System (ARTS), Differential (corrected) Global Positioning System (DGPS), Airport Movement Area Safety System (AMASS), and other technologies. ASTA will provide controllers with automatically generated alerts and cautions as well as data tags to identify all aircraft and special vehicles on the airport movement area in all-weather conditions. ASTA will also include a traffic planner that will improve the routing of aircraft on the taxiways and reduce taxi delay times. Future enhancements will include the Cockpit Display of Traffic Information (CDTI) for traffic on the surface. This is expected to be integrated with a CDTI capability for airborne traffic. The ASTA program examines the roles and responsibilities of controllers, pilots, and ground vehicle operators when operating on the airport.

The AMASS is an automation enhancement to the ASDE-3 primary ground sensor radar that provides an initial safety capability on runways and connecting taxiways. After determining that a group of ASDE-3 radar returns make up a target, the AMASS then analyzes that target's position and motions with respect to other targets and the defined airport operational configuration to determine if there are any conflicts among targets or with defined operations. If there are conflicts, a verbal and graphic alert is given to the controllers in the tower cab. The AMASS also has an interface with the Automated Radar Termi-

nal System (ARTS) in order to include airborne aircraft on final approach in the check for conflicting target operations on the airport surface. All airports slated to receive ASDE-3/AMASS equipment will also receive ASTA.

The ASTA program will share information with the Terminal Air Traffic Control Automation (TATCA) program to create an interrelated runway incursion prevention and surface traffic management system. When completed, the ASTA program will provide an all-weather, automated capability that allows for safer, higher capacity airport operations.

5.2 Terminal Airspace Capacity Technology

There are a number of programs that will improve the capacity of an airport's surrounding terminal airspace. The Precision Runway Monitor was discussed in Chapter 3 in connection with procedures for improved landing capabilities at airports with multiple runways. The Differential Global Positioning System (DGPS) and the Microwave Landing System (MLS) will make precision approach procedures available at more runways at more airports by significantly reducing the siting and frequency congestion problems associated with ILS.

The Center-TRACON Automation System will complement the above systems by aiding the controller in merging traffic as it flows into the terminal area. It will also support enhanced air traffic throughput and avoid undesirable bunching and gaps in the traffic flow on the final approach path. This system and the Converging Runway Display Aid have been combined into the Terminal ATC Automation Program. Finally, the Traffic Alert and Collision Avoidance System has the potential to expand beyond its current role of providing airborne collision avoidance as an independent system. It has the potential to reduce aircraft spacing in a variety of situations, leading to increased capacity.

5.2.1 Terminal ATC Automation (TATCA)

The purpose of the Terminal ATC Automation Program (TATCA) is to develop automation aids to assist air traffic controllers and supervisors in enhancing the terminal area air traffic management process and to facilitate the early implementation of these aids at busy airports. The TATCA program consists of two projects: the Converging Runway Display Aid (CRDA)/ Controller Automated Spacing Aid (CASA) and the Center-TRACON Automation System (CTAS). Longer-term TATCA ac-

tivities include the integration of terminal automation techniques with other air traffic control and cockpit automation capabilities.

5.2.1.1 Converging Runway Display Aid/ Controller Automated Spacing Aid

The CRDA displays an aircraft at its actual location and simultaneously displays its image at another location on the controller's scope to assist the controller in assessing the relative positions of aircraft that are on different approach paths. The CRDA function is now implemented in version A3.05 of the ARTS IIIA system.

Actual operations have shown that CRDA is effective in increasing capacity by allowing multiple runways to be used simultaneously under IFR.

The Controller Automated Spacing Aid (CASA) project is developing new applications to support the synchronizing of aircraft in separate streams of traffic.

Actual operations have shown that CRDA is effective in increasing capacity by allowing multiple runways to be used simultaneously under IFR. At St. Louis, the FAA has conducted a demonstration of this tool to measure its effect on dependent precision converging approaches in near Category I minimums. Results from field testing at St. Louis have shown an increase in arrival rates from 36 arrivals per hour to 48 arrivals per hour, an increase of 33 percent. National standards for CRDA were published in November 1992. Other airports such as Philadelphia International, Boston Logan International, Washington Dulles International, and Greater Cincinnati International are using or developing a use for CRDA.

While the original purpose of CRDA was to support specific procedures for converging approaches, other procedures can be supported by CRDA automation or a variant of that technology. The Controller Automated Spacing Aid (CASA) project is developing these other applications. In general, these new applications support the synchronizing of aircraft in separate streams of traffic. The applications range from support for more effective merging of aircraft in the terminal area prior to the approach phase to support for taking full advantage of available runway geometry with asymmetrical staggered approaches.

5.2.1.2 Center-TRACON Automation System

Approaches to major terminal areas represent one of the most complex and high-density environments for air traffic control. Arrivals approach from as many as eight directions, with jet arrivals descending from high altitudes while other traffic enters from low altitudes. It is difficult for controllers to foresee how traffic from one approach path will ultimately in-

teract with traffic from other approach paths. This results in traffic arriving either in bunches, which leads to higher controller workload and increased fuel burn to maintain separation, or with significant gaps, which in turn reduces airport capacity. Speed and space restrictions in the terminal area add to the difficulty of maintaining an orderly flow to the runway. Visibility and wind shifts, variations in aircraft mix, wake vortex considerations, missed approaches, runway changes or closings, all add to the difficulty of controlling traffic efficiently and safely in the terminal airspace.

CTAS is designed to improve system performance (e.g., efficiency, capacity, controller workload), while maintaining at least the same level of safety present in today's system, by helping the controller smooth out and coordinate traffic flow efficiently. The earliest CTAS product is the Traffic Management Advisor (TMA), with one TMA specifically designed for the Center environment (CTMA) and one for the TRACON (TTMA). The TMA determines the optimum sequence and schedule for arrival traffic, and coordination between air traffic control facilities such as a Center and a TRACON is managed via the TMAs for the respective facility. Other CTAS products are the Final Approach Spacing Tool (FAST) for the TRACON and a Descent Advisor (DA) for the ARTCC. FAST aids TRACON controllers in merging arrival traffic into an efficient flow to the final approach path and also supports controllers in efficiently merging missed approach and pop-up traffic into the final approach stream. DA assists Center controllers in meeting arrival times efficiently while maintaining separation.

CTAS is designed to improve system capacity while maintaining at least the same level of safety present in today's system, by helping the controller smooth out and coordinate traffic flow efficiently.

A CTAS functionality under concept exploration is Expedite Departure Path (EDP). EDP is intended to accurately model aircraft ascent up to cruise altitude. Ultimately this knowledge can be used in the terminal and en route environments to interleave departing aircraft into the existing flow of en route aircraft.

Each of the major components of CTAS, TMA (both CTMA and TTMA), DA, and FAST will be assessed in an operational environment at one or more sites prior to development and limited national deployment. Operational assessment of TMA began in 1993 and will continue in 1994. Operational assessments of FAST and DA will begin in 1994 and continue through 1995. Longer-term CTAS activities focus on integration of terminal automation with other ATC automation and cockpit automation activities.

5.2.2 Precision Runway Monitor (PRM)

The PRM consists of an improved antenna system that provides high azimuth and range accuracy and higher update rates, a processing system that monitors all approaches and generates controller alerts, and a high resolution display system.

Significant capacity gains can be achieved at airports with closely-spaced parallel runways if the allowable runway spacing for conducting independent parallel instrument approaches can be reduced. (The benefits associated with reduced spacing are discussed in Section 3.1.) Current criteria allow independent approaches to parallel runways separated by 4,300 feet or more. This standard was established based in part on the surveillance update rate and accuracy of the airport surveillance radars (ASRs) and the terminal Automated Radar Terminal System (ARTS) capabilities. Analysis and demonstrations have indicated that the separation between parallel runways could be reduced if the surveillance update rate and the radar display accuracy were improved, and special software was developed to provide the monitor controller with alerts. Conventional airport surveillance radars update the target position every 4.8 seconds.

The FAA fielded engineering models of the PRM system to investigate the reduction in separation associated with these improvements. The PRM consists of an improved antenna system that provides high azimuth and range accuracy and higher update rates than the current terminal ASR, a processing system that monitors all approaches and generates controller alerts when an aircraft appears to be entering the "no transgression zone" (NTZ) between the runways, and a high resolution display system. The E-SCAN PRM uses an electronically scanned antenna that is capable of updating aircraft positions every half a second.

Procedures to allow independent parallel operations for runways as close as 3,400 feet apart were published in 1991. Further research and development, including ATC simulations at the FAA Technical Center, are planned to determine the requirements for conducting independent parallel approaches to runways as close as 3,000 feet apart.

A contract was let in the spring of 1992 for procurement of five electronically scanned (E-SCAN) PRM antenna systems, with delivery planned for 1994.

5.2.3 Precision Approach and Landing Systems

The Instrument Landing System (ILS) has provided dependable precision approach service for many years. However, inherent characteristics of the ILS cause difficulties in congested terminal areas. Of particular concern from an air traffic per-

spective is the long straight-in flight path required by ILS. Although not a major concern for isolated airports without obstruction problems, for closely spaced airports, ILS finals often create conflicts because flight paths may cross in ways that preclude separation by altitude. In these configurations, the airports become interdependent (i.e., preferred operations cannot be conducted simultaneously at the affected airports), causing delays and constraining capacity. In areas such as New York, the curved approach capability provided by either the Microwave Landing System (MLS) or the Differential Global Positioning System (DGPS) will provide a solution to the interdependency of proximate airports.

MLS was designed to solve ILS difficulties in the terminal area. In the meantime, various implementations of DGPS have shown promise as precision approach and landing systems in initial research and development flight tests. A DGPS system would be based on the Department of Defense's (DOD's) Global Positioning System (GPS) augmented with ground reference stations and possible additional satellites to provide the accuracy, integrity, continuity, and availability of service required of a precision landing system. It is expected that DGPS will provide many of the same capabilities as MLS at a lower cost. To help determine the future precision approach and landing system for the National Airspace System (NAS), the FAA has initiated the National Airspace System Precision Approach and Landing System (NASPALS) study.

In general, the remote area navigation (RNAV) capability with wide-area coverage provided by MLS and DGPS will result in more flexibility in the terminal airspace. RNAV will permit the design of instrument approach procedures that more closely approximate traffic patterns used during VMC. Typically these result in shorter flight paths, segregation of aircraft by type, reduction of arrival and departure gaps, and avoidance of noise-sensitive areas.

MLS and DGPS will also enable the FAA to provide precision approach capability for runways at which an ILS could not be used due to ILS localizer frequency-band congestion or FM radio transmitter interference. For example, it is already difficult to add ILS facilities in congested areas such as Chicago and New York.

It may be possible to achieve lower minimums with MLS and DGPS than can be achieved with ILS at some sites. Moreover, both MLS and DGPS will relieve surface congestion resulting from restrictions caused by ILS critical area sensitivity to reflecting surfaces such as taxiing and departing aircraft.

Use of MLS or DGPS back azimuth for missed approach guidance may help support development of approach procedures for converging runways and triple runway configurations. Use of MLS or DGPS back azimuth for departure guidance will help ease airspace limitations and restrictions on aircraft operations due to noise abatement requirements.

Both MLS and DGPS will provide for more flexible ground siting of equipment to compensate for terrain irregularities that do not permit a centerline siting. Additionally, MLS and DGPS do not require as extensive a site preparation as the ILS glide slope, since they do not form guidance signals through ground reflection. One form of DGPS, known as the Wide Area Augmentation System (WAAS), could potentially provide a precision approach service at all runway ends. This technology would require equipment at a relatively few sites to establish the system. No site preparations would be required at individual airports.

The NASPALS study will be completed in late 1994. The recommendations provided by the study will be used in formulating the U.S. position on precision approach and landing systems for the International Civil Aviation Organization (ICAO) meeting scheduled for early 1995. At this meeting, ICAO members will reexamine the currently planned transition from ILS to MLS.

5.2.4 Traffic Alert and Collision Avoidance System (TCAS) Applications

TCAS is an airborne system that operates independently of ground-based ATC to provide the pilot with advisories concerning nearby transponder-equipped aircraft. The TCAS II system provides relative position information and, when necessary, advisories for vertical maneuvers to avoid collisions. This system is now fully implemented on transport category aircraft.

TCAS is an airborne system that operates independently of ground-based ATC to provide the pilot with advisories concerning nearby transponder-equipped aircraft. The TCAS II system, mandated for use in transport category aircraft, provides relative position information and, when necessary, advisories for vertical maneuvers to avoid collisions. This system is now fully implemented on transport category aircraft. A new version of the collision avoidance logic, which was developed to address operational issues that arose during its phased implementation, has been mandated for installation by December 31, 1994. Because of the situational information provided by TCAS and its widespread equipage, it has been identified as having the potential to increase ATC capacity and efficiency and reduce controller workload.

A program began in FY94 to investigate the use of TCAS to enable in-trail climb maneuvers through the altitude of another TCAS-equipped aircraft in the oceanic airspace. Air carrier ser-

vice trials of this procedure are slated to begin in late summer 1994. Later, it is anticipated that other programs will investigate the use of TCAS to extend visual approach procedures to lower minimums, support reduced spacing on final approach, reduce the stagger requirement for dependent converging approaches using the CRDA, allow departures at reduced spacing, and monitor separation between aircraft on independent approaches. Should these applications prove successful, additional development will be pursued in the areas of TCAS-based parallel approach monitoring, TCAS-based self-spacing, and other more advanced applications.

5.2.5 Wake Vortex Program

A better understanding of wake-vortex strength, duration, and movement could result in the reduction of aircraft separation criteria. Revised wake-vortex separation criteria may increase airport capacity by 12 to 15 percent in instrument meteorological conditions (IMC), thereby enhancing airspace use and decreasing delays.

Several vortex detection and measurement systems will be deployed at selected airports to monitor wake-vortex strength, transport characteristics, and decay. Wake vortex data obtained from these airports will be combined with data from tower fly-by tests already completed to provide a basis for reviewing existing separation standards and recommending modifications to those standards.

Plans include cockpit simulations to determine if separation standards for heavy aircraft operating behind heavy aircraft can be reduced from four miles in trail to three miles. This will be followed by examining the separation for large-behind-large and issues relating to closely spaced runways, departure delays, and departure sequencing which would interconnect with terminal automation.

5.2.6 Terminal Area Surveillance System

Although air traffic incidents may occur during any phase of flight, the largest percentage occur during takeoff and landing. Currently, there are many airports without surveillance radars, and the airport surveillance radar being procured by the FAA, the Airport Surface Detection Equipment-3 (ASDE-3), will not be available at all airports due to cost considerations. It is important, therefore, to develop affordable sensors to provide

a reliable surveillance source for terminal operations and to support automation development and airport capacity initiatives.

Requirements for a new terminal area surveillance radar have been identified and include modular, cost-effective primary and secondary radar systems with application for flexible, high capacity data links, improved surveillance accuracy, improved runway monitoring, improved wind shear detection and dissemination, and improved wake vortex tracking. Efforts will focus on adapting commercial technology in order to develop a radar that meets the validated requirements in a cost-effective manner.

5.3 En Route Airspace Capacity Technology

En route airspace congestion is being identified increasingly as a factor in restricting the flow of traffic at certain airports. Initiatives designed to reduce delays, match traffic flow to demand, and increase users' freedom to fly user-preferred routes are underway.

En route airspace congestion is being identified increasingly as a factor in restricting the flow of traffic at certain airports. One cause of en route airspace congestion is that ATC system users want to travel directly from one airport to another at the best altitude for their aircraft, and hundreds of aircraft have similar performance characteristics. Therefore, some portions of airspace are in very high demand, while others are used very little. This non-uniform demand for airspace translates into the need to devise equitable en route airspace management strategies for distributing the traffic when demand exceeds capacity. Initiatives designed to reduce delays, match traffic flow to demand, and increase users' freedom to fly user-preferred routes are underway.

Automated En Route Air Traffic Control (AERA) is a long-term evolutionary program that will increasingly allow aircraft to fly their preferred routes safely with a minimum of air traffic control intervention. The Advanced Traffic Management System (ATMS) will allow air traffic managers to identify in advance when en route or terminal weather or other factors require intervention to expedite and balance the flow of traffic.

The need for increased efficiency in oceanic airspace is also being addressed. Initiatives that improve the control of this airspace, particularly the more accurate and frequent position reporting resulting from Automatic Dependent Surveillance (ADS) using satellite technology, will make it possible to effect significant reductions in oceanic en route spacing.

Other means of improving en route airspace capacity include reducing the vertical separation requirements at altitudes above FL290 to allow more turbojet aircraft to operate along a given route near their preferred altitudes and reducing the minimum in-trail spacing to increase the flow rate on airways.

5.3.1 Automated En Route Air Traffic Control (AERA)

AERA is a collection of automation capabilities that will support ATC personnel in the detection and resolution of problems along an aircraft's flight path in coordination with traffic flow management. AERA will help increase airspace capacity by improving the ATC system's ability to manage more densely populated airspace. AERA will also improve the ability of the ATC system to accommodate user preferences. When the most desirable routes are unavailable because of congestion or weather conditions, AERA will assist the controller in finding the open route closest to the preferred one.

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Laboratory facilities for the AERA program were established in 1987. This laboratory has been used for prototyping and analyzing systems and concepts to develop operational and specification requirements, as well as supporting technical documentation. Initial algorithmic and performance specifications were completed in 1991. These specifications were updated in 1992 to reflect the transition strategy adopted to implement AERA capabilities. This strategy will minimize disruption of on-going operations and encourage effective assimilation of AERA capabilities by the controller work force.

In 1993, AERA was integrated into the En Route Automation Strategic Plan, which describes how en route automation programs will be incorporated into the National Airspace System over the next 7 to 10 years. Detailed implementation plans are being prepared to bring an initial AERA operational test capability to the field in late 1995 and to implement initial controller use of the AERA capabilities in late 1997. Full AERA capabilities are planned for initial use in the year 2000.

AERA concepts are being introduced in project planning and development for oceanic system automation, traffic flow management, and integration of en route and terminal ATC. In more advanced AERA applications, the integration of ground-based ATC and cockpit automation will be investigated to fully exploit the potential for computer-aided interactive flight planning between controller and pilot.

5.3.2 Automatic Dependent Surveillance (ADS) and Oceanic ATC

In the ADS System, the information generated by an aircraft's onboard navigation system is automatically relayed from the aircraft, via a satellite data link, to air traffic control facilities. The automatic position reports will be displayed to the air traffic controller in nearly real time. This concept will revolutionize ATC in the oceanic areas that are beyond the range of radar coverage. Currently oceanic ATC is largely manual and procedural and operates with very little, and often delayed, information. It depends upon hourly reports transmitted via High Frequency (HF) voice radio, which is subject to interference. Because of the uncertainty and infrequency of the position reports, large separations are maintained to assure safety. These large separations effectively restrict available airspace, and cause aircraft to operate on less than optimal routes.

ADS will be a part of an Oceanic ATC System to support transoceanic flights over millions of square miles of Pacific and Atlantic airspace. This Oceanic ATC system will provide an automation infrastructure including oceanic flight data processing, a computer-generated situation display, and a strategic conflict probe for alerting controllers to potential conflicts hours before they would occur.

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The new Oceanic ATC System will provide benefits to airspace users in efficiency and capacity. The improved position reporting will allow better use of the existing separation standards. Air traffic management will be able to begin the process of reducing those standards, thereby increasing the manageable number of aircraft per route. Using the strategic conflict probe, controllers will be able to evaluate traffic situations hours into the future. Ultimately, controllers will be able to grant more fuel-efficient flexible routes, which will have a significant impact on fuel costs and delays. The final decision to reduce separation standards in oceanic airspace is a joint decision shared by Air Traffic and Flight Standards. The Technical Programs Division (AFS-400) and the Procedures Division (ATP-100) are working together to develop the criteria and programs leading to the reduction of separation standards based on the introduction of Oceanic Datalink (ODS), GPS, and ADS.

5.3.3. Communications and Satellite Navigation

New technology enhancements in communications, navigation, and surveillance provide the basis for dramatic improvements in aviation system performance, including improved safety, reduced delay, increased capacity, and greater efficiency. These three functional areas represent key elements of the air traffic management infrastructure.

5.3.3.1 Aeronautical Data Link Communications

Data link services should relieve congestion on voice communications channels and provide controllers with an ability to handle more traffic during peak periods while providing pilots with unambiguous information and clearances. This benefit has been demonstrated by the delivery of pre-departure clearances via data link.

Data link applications are being developed based on inputs from the air traffic and aviation user communities. These applications include weather products, en route, terminal, and tower ATC communications, and other aeronautical services. The Aeronautical Telecommunications Network (ATN) allows use of many data link sub-networks (e.g., satellite, Mode S, VHF, etc.) in a way that is transparent to the users.

Domestic standards are being developed with RTCA, and the international standards, with ICAO. The en route, terminal, and tower ATC services are being developed and evaluated by a team of air traffic controllers. The operational aspects and benefits of data link applications will be verified using contractor and FAA Technical Center test beds. Pilot inputs will be gathered by connecting cockpit simulators and live aircraft to the test beds during evaluations.

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5.3.3.2 Satellite Navigation

Efforts are underway to augment the Department of Defense's Global Positioning System (GPS) to support civil aviation navigation requirements. Procedures and standards are being developed for oceanic and domestic en route, terminal, non-precision approach, precision approach, and airport surface navigation. Satellite ranging signals currently provide three-dimensional position, time, and velocity information that

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can be used as a supplemental means of navigation for civil users down to non-precision approach. This technology, supplemented to improve system accuracy, availability, and integrity, will eventually provide aircraft the ability to fly direct paths instead of being confined to specific routes, thus providing for more efficient use of airspace. GPS will also allow for increased capacity through reduced separation minimums and provide an accurate position reporting system without separate surveillance systems.

With the declaration of GPS initial operational capability (IOC) in December 1993, the DOD agreed to sustain levels of signal availability and accuracy such that basic federal radio navigation requirements are met. Furthermore, the Joint DOD/Department of Transportation (DOT) Task Force Report, released in December 1993, gave the FAA authority to implement a wide-area integrity and availability enhancement to support expanded civil navigation operations. With demonstrated improvements in position accuracy, GPS may prove capable of providing an all-weather landing service by the turn of the century.

The satellite navigation program is working with the communications, navigation, surveillance (CNS)/satellite system manager and systems engineering to transition to the future National Airspace System Precision Approach and Landing System (NASPALS). Candidate system architectures being developed and evaluated are hybrids of space and terrestrial-based systems, including GPS. The goal of the program is to compare the performance, cost, operational capability, and risk of each architecture and select the best candidate as the U.S. position for international standardization.

Weather is the single most important factor in delays and a major factor in aircraft accidents and incidents. Improved weather information can not only increase system capacity, but also enhance flight safety, improve flight efficiency, reduce ATC and pilot workload, improve flight planning, and result in fuel and cost savings.

5.3.4 Aviation Weather

Weather is the single most important factor in delays and a major factor in aircraft accidents and incidents. Improved weather forecasts offer the potential for increasing system capacity more cost effectively than many other alternatives. Improved weather information can not only increase system capacity, but also enhance flight safety, improve flight efficiency, reduce ATC and pilot workload, improve flight planning, and result in fuel and cost savings.

Efforts are underway to enhance our understanding and ability to predict a range of aviation weather phenomena: icing, en route and transition turbulence; ceiling and visibility; thunderstorms and microbursts; en route and terminal wind; and oceanic weather of all kinds. Models and algorithms are being

developed for understanding weather and generating short-term forecasts.

To help in the understanding of weather, airborne meteorological sensors are being developed to measure humidity and turbulence. These sensors will be carried aboard aircraft to provide near-real and real-time three-dimensional weather data that is currently not available.

Wind shear is a major cause of weather-related fatalities in the air carrier community. Research is underway to develop advanced wind shear warning systems and flight crew decision aids. The technology will be transferred to manufacturers and operators to accelerate the development of these systems. Once developed, flight tests will be conducted to evaluate onboard airborne wind shear sensor performance by flying the test aircraft into wind shear. Also, a wind shear training program will be developed for air taxis, commuter operators, and general aviation.

5.4 Traffic Flow Management

The development of improved capabilities to support national and local traffic flow managers has received increasing attention in recent years, and a number of efforts are underway to aid in fielding effective and well designed enhancements to the Traffic Flow Management (TFM) System. Two of the most prominent such efforts are the Advanced Traffic Flow Management System (ATMS) and the Operational Traffic Flow Planning (OTFP) Program. Both of these efforts will focus on formulating and developing improvements for the TFM system in consultation with aviation system users, including both the automation infrastructure and the associated air traffic procedures necessary to implement the operational capability.

5.4.1 Advanced Traffic Management System (ATMS)

The purpose of the ATMS effort is to research automation tools to minimize the effects of NAS overload on user preferences without compromising safety. This is accomplished by:

- Monitoring the demand on and capacity of ATC resources.
- Developing alternative strategies to balance demand and capacity to prevent critical entities from being overloaded.
- Coordinating and implementing strategies to assure maximum use of critical resources when a demand/capacity imbalance is predicted or detected.

The Aircraft Situation Display (ASD) was the first capability developed by ATMS.

The ASD has helped increase system capacity in several ways. It allows traffic management specialists to observe approaching traffic across ARTCC boundaries. This has allowed the reduction or elimination of many fixed miles-in-trail restrictions. It assists traffic management specialists in planning arrival flows for airports that are close to ARTCC boundaries. It allows traffic management specialists to detect and effect solutions to certain congestion problems.

Automation tools shown to be beneficial through the ATMS research and development program will be implemented and fielded for operational use in the Enhanced Traffic Management System (ETMS).

The Aircraft Situation Display (ASD) was the first capability developed by ATMS. The ASD generates a graphic display that shows current traffic and flight plans for the entire NAS. The ASD is currently deployed at the Air Traffic Control System Command Center (ATCSCC) and all ARTCCs and at selected TRACONs and Canadian locations. The ASD data has also been provided to commercial air carriers and air taxi operators, and they are using these data to aid in their operations management and planning.

The ASD has helped increase system capacity in several ways. It allows traffic management specialists to observe approaching traffic across ARTCC boundaries. This has allowed the reduction or elimination of many fixed miles-in-trail restrictions (and the resultant delay of aircraft) that were in effect prior to the deployment of ASD. It assists traffic management specialists in planning arrival flows for airports that are close to ARTCC boundaries, resulting in smoother arrival flows and better airport utilization. It allows traffic management specialists to detect and effect solutions to certain congestion problems, such as merging traffic flows, well in advance of problem occurrence and even before the aircraft enter the ARTCC where the congestion problem will occur. Small adjustments to traffic flows made early can avoid large delays associated with last-minute solutions.

The second capability developed by ATMS was the Monitor Alert, which predicts traffic activity several hours in advance. It

compares the predicted traffic level to the threshold alert level for air traffic control sectors, fixes, and airports, and highlights predicted problems. It will aid in detecting congestion problems further in advance, enabling solutions to be implemented earlier. The Monitor Alert has recently been implemented at the ATCSCC, all ARTCCs, and several TRACONs.

Four future capabilities that are being developed through ATMS are Automated Demand Resolution, Dynamic Special Use Airspace, Strategy Evaluation, and Automated Execution. Automated Demand Resolution will examine problems predicted by Monitor Alert and suggest several alternative problem resolutions. The suggested resolutions are planned to respond to each problem without creating conflicts or additional problems. Dynamic Special Use Airspace will provide automation to allow consideration of actual and scheduled military operations in the national flow management decision making process. Strategy Evaluation will provide a tool to evaluate alternative flow management strategies. Automated Execution will generate and distribute facility and aircraft-specific directives to implement selected strategies.

In addition to domestic flow management capabilities, research is being conducted for oceanic flow management capabilities. Track Generation will define a set of tracks for a prescribed region of airspace. Track Advisory will advise oceanic traffic managers of the most efficient tracks available to individual aircraft approaching the track system. Oceanic Traffic Display will assist the oceanic traffic manager in routing aircraft. Further development will concentrate on the integration of domestic and oceanic capabilities.

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5.4.2 Operational Traffic Flow Planning (OTFP)

Increasing congestion, delays, and fuel costs require that the FAA take immediate steps to improve airspace use, decrease flight times and controller workload, and increase fuel efficiency. To achieve these objectives the FAA Operational Traffic Flow Planning program will develop near-term, operational traffic planning models and tools. The program will provide software tools to plan daily air traffic flow, predict traffic problems and probable delay locations, assist in joint FAA-user planning and decision-making, and generate routes and corresponding traffic flow strategies which minimize time and fuel for scheduled air traffic. Benefits include improved aviation safety, airspace use, system throughput, and route flexibility.

The FAA Operational Traffic Flow Planning program will develop near-term, operational traffic planning models and tools. The program will provide software tools to plan daily air traffic flow, predict traffic problems and probable delay locations, assist in joint FAA-user planning and decision-making, and generate routes and corresponding traffic flow strategies which minimize time and fuel for scheduled air traffic.

Working directly with commercial aviation interests and other FAA facilities, the Air Traffic Control System Command Center (ATCSCC) can predict problem areas before they occur and generate alternative reroutings and flow procedures. Overall system capacity will be increased over that of the present fixed route and rigid preferred route systems, and increased fuel efficiency, shorter travel times, and reduced delays will result. Controller workloads will decrease from users' participation in a planned, systematic flow of traffic.

5.5 System Planning, Integration, and Control Technology

The NSC is a unique capability that will exploit the latest simulation technology. Horizontal integration brings together diverse system components such as terminal automation, en route automation, oceanic air traffic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment.

The following sections describe technologies that support planning to integrate various improvements into the NAS. Both operational improvements and new technologies need to be evaluated so that they can be developed and implemented effectively, ensuring the interoperability of the elements of the NAS. A large number of models and other technologies will support this integration effort. The National Simulation Capability (NSC), for example, will horizontally integrate many of these new technologies in a laboratory environment. The National Airspace System Performance Analysis Capability (NASPAC) will help in the identification of demand/capacity imbalances in the NAS and provide a basis for evaluation of proposed solutions to such imbalances. Computer-graphics tools, such as the Sector Design Analysis Tool and the Terminal Airspace Visualization Tool, will allow airspace designers to quickly and effectively develop alternative airspace sectors and procedures. They will also reduce the time and effort required to implement these alternatives.

5.5.1 National Simulation Capability (NSC)

The NSC aids and supports the RE&D and systems engineering missions of the FAA by horizontally integrating the various RE&D program elements across the National Airspace System (NAS) environment. The capability to integrate emerging ATC subsystems during the conceptual stage of each project allows early validation of requirements, identification of problems, development of solutions to those problems, and demonstration of system capabilities. It also permits early injection of human factors and system user inputs into the concept formulation process. The net result is a reduction of risk in the devel-

opment of products for the NAS, faster infusion of new technology, earlier acceptance of new NAS concepts by system users, and greater efficiency in performing the RE&D and systems engineering missions. The ASTA, CTAS, TCAS, AERA, ATMS, OTFP, Aeronautical Data Link Communications, Terminal Area Surveillance System, and Aviation Weather programs are all actively involved in horizontal system simulations in the NSC.

The NSC is a unique capability that will exploit the latest simulation technology. Horizontal integration brings together diverse system components such as terminal automation, en route automation, oceanic air traffic control, aircraft flight management systems, and mixes of aircraft types and performance in a flexible, interchangeable, and dynamic simulation environment. It provides an ability to assess the suitability and capability of emerging ATC system components before production investment decisions are made. The NSC permits the evaluation of new operational concepts, human interfaces, and failure modes in a realistic, real-time, interactive ATC environment capable of simulating new or modified systems at forecast traffic levels. Simulation capabilities will be expanded through an interface with various remote research centers that possess nationally unique facilities and expertise.

5.5.2 Analysis Tools

A large and growing repertoire of analytical, simulation, and graphical tools and models are being developed and used to help understand and improve the NAS. Some of the more prominent of these are briefly described in the following sections.

The principal objectives of computer simulation models currently in use and under development are to identify current and future problems in the NAS caused by demand/capacity imbalances and to construct and evaluate potential solutions. All of the models rely on a substantial amount of operational data to produce accurate results. The principal models that are being developed and are in use today are described below.

5.5.2.1 Airport Network Simulation Model (AIRNET)

AIRNET is a PC-based tool that is designed to assess the impact of changes in airport facilities, operations, and demand. It is a planning tool that can assess the effects of those changes on passenger costs, noise contours, airports, airlines, and aircraft. It addresses macro trends and interactions for use in policy planning and economic analysis.

5.5.2.2 Airport and Airspace Simulation Model (SIMMOD)

SIMMOD simulates both airports and airspace in a selected geographic area. It aids in the study of en route air traffic, terminal air traffic, and ground operations. It is capable of calculating capacity and delay impacts of a variety of operating alternatives, including runway configurations, airspace routes, sectorization, and separation standards. It is a planning tool for evaluating operational alternatives involving the coordination of airport configurations with airspace configurations. SIMMOD has been used in airspace design studies around major airports. Improvements to SIMMOD include better output displays, automated data-acquisition capability, and a workstation version of the model.

5.5.2.3 Airfield Delay Simulation Model (ADSIM) and Runway Delay Simulation Model (RDSIM)

The Airfield Delay Simulation Model (ADSIM) calculates travel time, delay, and flow rate data to analyze components of an airport, airport operations, and operations in the adjacent airspace. It traces the movement of individual aircraft through gates, taxiways, and runways. The Runway Delay Simulation Model (RDSIM) is a sub-model of ADSIM. RDSIM limits its scope to the final approach, runway, and runway exit.

5.5.2.4 The Airport Machine

The Airport Machine is a PC-based interactive model with graphics that is used to evaluate proposed changes to airfield and terminal configurations, schedules, and aircraft movement patterns. This model has been licensed for use within the FAA and has been used in studies of a number of major airports. Its primary output is extensive data on delays to aircraft movement.

5.5.2.5 National Airspace System Performance Analysis Capability (NASPAC)

The NASPAC Project provides a long-term analysis capability to assist the FAA in developing, designing, and managing the Nation's airspace on a system-wide level through the application of operations research methods and computer modeling. The focal point of the NASPAC Project is the NASPAC Simulation Modeling System (SMS). The NASPAC SMS is a simulation of the entire NAS used to estimate flight delays by modeling the progress of individual aircraft as they move through the nationwide network of airports, en route sectors, routes, navigation fixes, and flow control restrictions. The model has been used to study the current and projected performance of the NAS and to study system improvements such as new airports, new runways, and airspace changes, as well as projected demand changes such as the creation of new air carrier hubs and the introduction of civil tiltrotor flights in the Northeast Corridor.

5.5.2.6 Sector Design Analysis Tool (SDAT)

The SDAT is an automated tool to be used by airspace designers at the 20 Air Route Traffic Control Centers (ARTCCs) to evaluate proposed changes in the design of airspace. This computer model allows the user to input either the current design or the proposed replacement. It also allows the user to interactively make changes to the design shown graphically on the computer screen.

The model allows the user to play recorded traffic data against either the actual design or the proposed replacement. It also allows the user to modify traffic data interactively in order to evaluate alternative designs under postulated future traffic loading. The model computes measures of workload and con-

flict potential for the specified sector or group of sectors. This will allow designers to obtain a better balance in workload between sectors, reducing controller workload and increasing airspace capacity. The model will also be useful for facility traffic flow managers, for it will display cumulative traffic flows under either historic or anticipated future traffic loading.

The development of the SDAT has been underway for approximately three years. Procedures for extracting and displaying (in 2D and 3D) all the requisite data from available FAA data files and computing the expected demand for separation assurance actions have been developed. The development of a fully capable controller workload model is underway. SDAT was field tested at two selected sites in FY93, with expanded testing planned for FY94.

A procedure for using the SDAT as an airspace model (assuming that controller workload is the limiting factor) is under development. This will be combined with an on-line Critical Sector Detector for traffic flow management. In addition, a version for terminal area design is under development.

5.5.2.7 Terminal Airspace Visualization Tool (TAVT)

Terminal airspace differs from en route airspace in that it tends to have a more varied mix of aircraft and user types, more complicated air traffic rules and procedures, and wider variation in flight paths. A major redesign of terminal airspace currently requires extensive coordination and the effort of a task force lasting many months or even years. The purpose of the TAVT prototype is to explore the potential for computer-based assistance to such a task force that will support a more rapid evaluation of alternatives.

The TAVT prototype displays a three-dimensional representation of the airspace on a large computer screen to allow the user/operator to view the airspace from any perspective. It also provides an easy-to-use interface that permits the user to modify the airspace according to permissible alternatives. The results of this effort are being evaluated for incorporation into the specifications of a follow-on terminal airspace design tool based on SDAT.

5.5.2.8 Graphical Airspace Design Environment (GRADE)

GRADE is a computer graphics tool for displaying, analyzing, and manipulating airspace design and other aviation related data. Radar data (from both ARTS and SAR) are stripped from their recording media and loaded into GRADE's underlying relational database along with the appropriate airspace geometries, terrain maps, National Airspace System (NAS) data, descriptions of routes, and any other data required in the analysis. GRADE can then be used to test proposed terminal instrument procedures (TERPS), standard terminal arrival routes (STARs) and standard instrument departures (SIDs), airspace design changes, and instrument approach procedures.

GRADE can display radar data in three dimensions, along with the attendant flight plan information, for any given time slice. GRADE also includes a set of algorithms designed to measure interactions between the radar data and any other elements of the database. These measurements can then be displayed as histograms and compared. GRADE provides a high quality, three-dimensional presentation, is relatively easy to use, and can be quickly modified to facilitate the comparison of existing and proposed airspace designs and procedures.

GRADE is currently limited to airspace design applications, but could easily be adapted to other applications, such as noise analysis, interaction with existing airport and airspace computer simulation models, accident/incident investigation (particularly for aircraft without flight data recorders), and training in lessons learned and alternate air traffic control techniques.

5.6 Vertical Flight Program

The Vertical Flight Program will help improve the safety and efficiency of vertical flight operations and increase the capacity of the NAS through research, engineering, and development into air traffic rules and operational procedures, heliport/vertiport design and planning, and aircraft/aircrew certification and training.

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The term vertical flight (VF) includes conventional rotorcraft (helicopters) as well as advanced technology designs for aircraft with the ability to hover and take off and land vertically. The Rotorcraft Master Plan (RMP) envisions advanced VF technologies providing scheduled short-haul passenger and cargo service for up to 10 percent of projected domestic air transportation needs. Recognizing the potential for advanced

VF aircraft to provide passenger service, Public Law 102-581 requested that a Civil Tiltrotor (CTR) Development Advisory Committee be established to evaluate the technical feasibility and economic viability of developing CTR aircraft and infrastructure to support the incorporation of tiltrotor technology into the national transportation system.

Air infrastructure research will focus on the ability to conduct all-weather and IFR operations at heliports and vertiports in terminal airspace without interfering with fixed-wing traffic flow. Much of the initial work relating to emerging technologies will be done through simulation and validated with actual flight test data as the aircraft become available.

Ground infrastructure research will provide RE&D into heliport and vertiport design and planning issues, including the terminal area facilities and ground-based support systems that will be needed to implement safe, all-weather, 24-hour flight operations. Developing obstacle avoidance capabilities is a critical design-related effort. Research will include applying lessons learned from detailed accident and rotorcraft operations analyses. Simulation will be used to collect data, analyze scenarios, and provide training to facilitate safe operations.

Aircraft/aircrew research will develop minimum performance criteria for visual scenes and motion-based simulators; evaluate state-of-the-art flight performance for cockpit design technology; develop improved training techniques employing expert decision making, and develop crew and aircraft performance standards for display and control integration requirements. Research will also be conducted to develop certification standards for both conventional and advanced technology VF aircraft.

Chapter 6

Marketplace Solutions

Marketplace solutions to aviation system capacity problems rely primarily on competitive, free-market influences. They involve the interests not only of the airlines and airport authorities but also of other aviation industry groups, local government organizations, and local communities. This diversity of special interests makes predicting, managing, and integrating marketplace solutions inherently difficult. To add to the difficulty, the major air carriers today continue to face the uncertainty of increasing costs and decreasing revenues. However, operating losses were less widespread in 1993 than in 1992, and over half of the major carriers made an operating profit. In fact, the airline industry seems to be undergoing an evolutionary step that includes an increase in the importance of lower-cost regional/commuter airlines and a relative decline in the importance of hubs.

The growth of the regional/commuter airlines continues to outpace the growth of the larger air carriers. Small- and medium-market routes, without enough traffic to support the larger jets of the major air carriers, can support small jets and turboprops.

6.1 Regional/Commuter Carriers

The growth of the regional/commuter airlines, i.e., air carriers that provide regularly scheduled passenger service and whose fleets are composed predominantly of aircraft having 60 seats or less, continues to outpace the growth of the larger air carriers.[1] Total revenue passenger enplanements for the regional/commuter airlines increased by 10 percent in 1993. The major air carriers have been dropping short-haul routes on which they are losing money, and these markets are being served profitably by regional/commuter carriers. Small- and medium-market routes, without enough traffic to support the larger jets of the major air carriers, can support small jets and turboprops. In addition, these smaller aircraft can meet demands for high-frequency service. Frequent flights attract business as well as leisure travelers. The introduction of new state-of-the-art aircraft is also expected to contribute to greater public acceptance and stimulate higher growth.

1. Based on FAA Aviation Forecasts, Fiscal Years 1994-2005, FAA–APO 94–1, March 1994.

Regional/commuter airlines have been marked by an increased integration of operations with the operations of the large air carriers through code-sharing agreements and acquisition of regional/commuter carriers by the large air carriers. Many of the regional/commuter airlines are owned, totally or in part, by their larger code-sharing partners, and still others are owned by other regional/commuter airlines. In addition, the industry has become more and more concentrated, and, with the decline in the number of carriers, the largest regional/ commuter airlines account for most of the passenger enplanements.

The smaller regional/commuter carriers often bypass hub airports and provide direct, point-to-point service between cities that were previously connected only through a hub. This frees slots at the often overcrowded hub airports, thus increasing capacity and easing congestion and delay.

The larger regional/commuter carriers generally provide high-frequency flights directly to hub airports to feed passengers to the major carriers. Their flights are timed to connect with the flights of the major carriers they feed. The increasing number of these regional/commuter carrier flights uses up capacity at the hub airport. The mix of smaller, slower aircraft with the large jets of the major air carriers can also complicate air traffic control procedures, adding further to the congestion and delay at the airport. At hub airports with well-established networks of regional feeder airlines, like Seattle-Tacoma International in the Pacific Northwest and Boston Logan International in northern New England, air taxi/commuter aircraft account for about 40 percent of total operations.

The emerging technology of tiltrotor aircraft could absorb much of the demand for short-haul flights of 500 miles or less.

VSTOL aircraft have the potential to reduce runway usage since they are not runway dependent.

To integrate tiltrotor and other VSTOL aircraft into the aviation system, an infrastructure must be developed that addresses the special needs of vertical flight.

6.2 Civil Tiltrotor

The emerging technology of tiltrotor aircraft could absorb much of the demand for short-haul flights of 500 miles or less. Tiltrotor is still considered by many to be an unknown and costly technology. Tiltrotor aircraft have yet to be proven technically feasible and economically competitive in the commercial market. However, the expected higher operating costs of the tiltrotor may be partially offset by the delay-cost savings that would result from reduced airport congestion and the convenience and other economic benefits that would accrue to passengers and other users.

These vertical- or short-take-off-and-landing (VSTOL) aircraft have the potential to reduce runway usage since they are not runway dependent. Vertiports at hub airports would free runway slots and provide additional airfield capacity for con-

ventional, fixed-wing aircraft. Vertiports in cities would provide service from city center to city center, bypassing airports altogether. If successful, tiltrotor aircraft may eventually replace conventional regional/commuter aircraft on the short-haul routes that link airports near smaller cities and towns with large hub airports and major city centers. Vertiports promise to be less disruptive to local communities than wholesale airport runway expansions.

To integrate tiltrotor and other VSTOL aircraft into the aviation system and take advantage of their capability to land on other than a runway, an infrastructure must be developed that addresses the special needs of vertical flight. Vertiports and separate air traffic control procedures for instrument flight rules (IFR) must be developed that do not significantly affect conventional aircraft operations.

6.3 The Next Generation of Aircraft

The effects of next-generation aircraft need to be considered in the long-range planning for airport expansion. For example, the world's major aircraft manufacturers are developing plans for a 500- to 800-seat superjumbo jet intended for the very high density inter-city and long-range intercontinental routes that could support such a large aircraft. These new superjumbo jets would be double-deck aircraft weighing 1.2 million pounds or more, with a wingspan of at least 260 feet, and a length of 260 or more feet. Compare this to a Boeing 747-400, with a maximum takeoff weight of about 830,000 pounds, a wingspan of 213 feet, and a length of 232 feet.

Larger aircraft capable of carrying more passengers bring the economies of scale that would enable airlines to cut costs and contend with congested airports that are limited in size and unable otherwise to expand their capacity.

And, it is not just the largest intercontinental airports that would be affected by new, larger aircraft. The Boeing 777 will be a widebody twin jet capable of carrying about 400 passengers for distances of up to 4,200 nautical miles (nm). The B-777 aircraft will have a wingspan of nearly 200 feet, and Boeing is considering an optional folding-wing design that would reduce the aircraft's wingspan on the ground and permit the aircraft to operate at tight-geometry airports like LaGuardia. In addition, the new aircraft will have a maximum gross takeoff weight of about 590,000 pounds, and later, stretched versions of the aircraft may have a maximum gross takeoff weight as high as 650,000 pounds.

These new aircraft, then, will result in major new demands on airports. Their larger size, significantly greater weight, and large number of passengers would require redesigned terminals and gate areas, new ground support facilities, increased pavement strengths for runways, taxiways, and aprons, and wider

taxiway separations. Larger aircraft capable of carrying more passengers bring the economies of scale that would enable airlines to cut costs and contend with congested airports that are limited in size and unable otherwise to expand their capacity.

6.4 Airport Expansion and the Local Community

Marketplace solutions to airport capacity problems include the development of new hub airports, the expanded use of existing commercial service airports, the expanded use of reliever airports, the joint civilian and military use of existing military airfields, and the conversion of former military airfields to civilian use.

A community's overall acceptance of airport expansion and increased airport activity is often predicated on the perception of aircraft noise, rather than actual noise levels. In order to generate community support for capacity increases, it is essential that airport operators are seen by their communities as working to control noise levels and mitigate noise impacts. Curfews and other noise restrictions can be inconvenient for passenger carriers, but they create particular problems for air-cargo firms that must fly at night to provide morning delivery of packages and freight. In addition, cargo carriers tend to rely on older passenger aircraft that have been remodeled to handle cargo, and these aircraft often produce more noise than newer jets. Older Stage II aircraft are to be phased out and completely replaced by the much quieter Stage III aircraft by the year 2000. This will greatly reduce the area around an airport affected by aircraft noise and is likely to reduce local opposition to airport development.

Airport development can generate additional jobs and airport revenues, encourage land development, and otherwise stimulate economic growth. Information on this economic impact has proven useful in generating public support for proposed airport improvements, and airports must focus on their overall effect on the local economies. An economic impact analysis can provide an estimate of the economic significance of an airport to the surrounding area. Direct impact is related to specific projects, services, and facilities at an airport. Indirect impact is linked to the economic activities of off-site enterprises serving airport users, such as hotels.

Airlines and other airport users will seek solutions for a delay-problem airport when the delays there are no longer tolerable. But before such a decision is made, the solution must make operational and economic sense. Airlines conduct marketing surveys and feasibility studies to verify such things as the adequacy of the origin and destination market and the economic viability of their proposed investment. Airport authorities, local communities, and other interested members of the aviation industry can facilitate an airline's decision process by conducting their own surveys and studies. But, in addition,

they must advertise and market within the industry not only the characteristics of their airport that make it a good choice for the airlines, but also the willingness of the local community to absorb the increased traffic.

Examples of marketplace solutions to airport capacity problems include the development of new hub airports, the expanded use of existing commercial service airports, the expanded use of reliever airports, the joint civilian and military use of existing military airfields, and the conversion of former military airfields to civilian use.

6.4.1 New Hubs at Existing Airports

As one solution to the growth in flight delays at traditional connecting hub airports, airlines may develop new hubs at existing airports. A new connecting hub could produce delay savings by diverting some of the growth that would otherwise occur at nearby primary hub airports. Hub airports developed since airline deregulation have exhibited the following characteristics:

- strong origin and destination market,
- good geographic location,
- expandable airport facilities,
- multiple IFR approach capabilities,
- strong local economy and availability of balanced work force, and
- ability to accommodate existing/planned service.

More than two dozen potential new hub airports have been identified in the vicinity of airports with forecast delay problems. Each has the potential to permit multiple approach streams under IFR.

More than two dozen potential new hub airports have been identified that are located more than 50 miles from airports with forecast delay problems and have the potential runway capacity to accommodate significantly increased airport operations. Each has the potential to permit multiple approach streams under IFR. Hence, they meet the first, second, and fourth characteristics. Other airports may meet the third and fourth characteristics through appropriate capital investment. Additional analysis would be required to determine which airports have viable economies, both from the local and airline perspective, as well as the local support needed for expansion into a hub airport. Appendix I provides an example of the type of analysis that may be performed to determine the potential consequences of establishing a new hub airport. The example is based on *A Case Study of Potential New Connecting Hub Airports, Report to Congress* and looks at four airports, Huntsville

International Airport, Port Columbus International Airport, Sacramento Metropolitan Airport, and Oklahoma City Will Rogers World Airport.

6.4.2 Expanded Use of Existing Commercial Service Airports

Expanded use of nearby airports that already have commercial service can ease congestion in a particular market.

This offers an ideal strategy for airlines providing short-haul, regional service, particularly for an airline emphasizing point-to-point service.

Expanded use of nearby airports that already have commercial service can ease capacity problems at primary hub airports by spreading commercial aircraft operations among additional airports near the primary airport. In contrast to new hubs, the expanded use of existing commercial service airports is primarily intended to relieve congestion in a particular market, not to constitute a market of its own.

This offers an ideal strategy for airlines providing short-haul, regional service, particularly for an airline emphasizing point-to-point service rather than feeding passengers to the major carriers at the hub airports. The regional carrier can move into a nearby underutilized airport, where they can operate at lower cost, avoid the congestion and costly delays caused by overcrowding, and avoid direct competition with the major carriers.

For each of the 23 current delay-problem airports, a preliminary list of airports located in the vicinity and served by commercial air traffic, was compiled. This is shown in Table 6-1. A number of military airports and airports not currently served by commercial air traffic have been added to the list. As congestion becomes greater at the delay-problem airports, passengers may choose to travel to the alternative airports. This traffic diversion would tend to decrease delays at the delay-problem airport.

Table 6-1. Preliminary List of Airports Located Near the 23 Delay-Problem Airports

Delay-problem Airport†		Supplemental Airport
Atlanta Hartsfield	ATL	Athens
		Macon
		Columbus (100 mi)
		Chattanooga, TN (100 mi)
Boston	BOS	Manchester, NH
		Portland, ME
		Portsmouth, NH
		Providence, RI
		Worcester, MA
		Bedford, MA
		Ashville (100 mi)
Charlotte	CLT	Hickory
		Greensboro (90 mi)
		Greer, SC (90 mi)
		Winston-Salem (60 mi)
		Columbia, S.C. (100 mi)
Chicago O'Hare	ORD	Aurora
		Chicago Midway
		Meigs Field
		Rockford
		Waukegan
		West Chicago (Du Page)
		Wheeling
		Gary, IN
		NAS Glenview
Dallas-Ft. Worth	DFW	NAS Fort Worth, Joint Reserve Base (formerly Carswell AFB)
		Dallas-Love Field
		Denton
		Fort Worth Alliance
		Fort Worth Meacham
		McKinney
		Mesquite
		Waco (80 mi)
Denver	DEN	Colorado Springs (80 mi)
Detroit	DTW	Detroit City
		Flint
		Pontiac
		Lansing (80 mi)
		Toledo, OH (60 mi)
		Selfridge ANG
		Willow Run
		Windsor, Ontario, Canada
Honolulu	HNL	Kailua
Houston	IAH	Corpus Christi
		Ellington
		Galveston
		Houston Hobby
Los Angeles	LAX	Burbank
		Long Beach
		Ontario
		Oxnard
		Palmdale
		San Bernardino
		Santa Ana
Miami	MIA	Ft. Lauderdale
		West Palm Beach
Minneapolis	MSP	St. Paul (Downtown)
		Mankato (60 mi)
		Rochester (77 mi)
		Eau Claire, WI (85 mi)
		St. Cloud (70 mi)
New York	JFK	Farmingdale
		Islip/Long Island
		Stewart/Newburgh (60 mi)
		White Plains
Newark	EWR	Trenton
		Stewart/Newburgh, NY (60 mi)
		White Plains, NY
		Atlantic City, NJ
		Morristown
		Essex County
		Teterboro
Orlando	MCO	Daytona Beach
		Ft. Pierce (100 mi)
		Gainsville (100 mi)
		Melbourne (60 mi)
		Tampa (70 mi)
		Vero Beach (90 mi)
Philadelphia	PHL	Allentown
		Lancaster (70 mi)
		Reading (60 mi)
		Willow Grove NAS
		Trenton, NJ
		Atlantic City, NJ
		Wilmington, DE
Phoenix	PHX	Prescott (80 mi)
		Williams Gateway
		Tucson (110 mi)
Pittsburgh	PIT	Johnstown
		Latrobe
		Morgantown, WV (60 mi)
San Francisco	SFO	Concord
		Oakland
		San Jose
		Santa Rosa
		Moffett Field NAS
		Hamilton Field
St. Louis	STL	Scott AFB
Seattle	SEA	Everett/Paine Field
		McChord AFB
Washington	DCA	Baltimore, MD
		Hagerstown, MD (60 mi)
		Charlottesville, VA (100 mi)
		Richmond, VA (100 mi)
		Andrews AFB
Washington	IAD	Baltimore, MD
		Hagerstown, MD (60 mi)
		Charlottesville, VA (100 mi)
		Richmond, VA (100 mi)
		Andrews AFB

† Airports having greater than 20,000 hours of delay for 1993 as reported by FAA Office of Policy and Plans.

6.4.3 Enhance Reliever and General Aviation (GA) Airport System

The segregation of aircraft operations by size and approach speed increases effective capacity at each airport type because required time and distance separations are reduced between planes of similar size.

General Aviation (GA) provides access to more than 17,000 facilities in the Nation's air transportation system. By providing on-demand direct transportation to all of these locations, GA enhances overall system capacity in our NAS and extends access to millions of customers.

In FY95, a group consisting of FAA and industry representatives will convene to review the current FAA airspace capacity plan and policies in determining whether general aviation should be recognized within those FAA documents as a system wide capacity "enhancer." This effort will necessitate an inclusion of contemporary discussions of the "Free Flight" concept and its potential to enhance capacity in the national airspace system. The group will also explore the possibility of creating a national airports policy that seeks to maintain or increase the number of public access airports available to general aviation and to create a practical and viable system of reliever airports.

Reliever and GA airports ease capacity problems at primary airports by attracting smaller/ slower aircraft away from delay-problem airports. The segregation of aircraft operations by size and approach speed increases effective capacity at each airport type because required time and distance separations are reduced between planes of similar size.

The FAA provides assistance for construction and improvements at reliever airports under the Airport Improvement Program. The objective of this assistance is to increase utilization of reliever airports by building new relievers, improving the facilities and navigational aids at existing relievers, and reducing the environmental impact on neighboring communities. Because they serve primarily general aviation aircraft, reliever airports can be effective with significantly less extensive facilities than commercial service airports.

Reliever airports can be expected to play significant roles in reducing congestion and delay at delay-problem airports, especially those where small/slow aircraft constitute a significant portion of operations. Of the 32 airports forecast to exceed 20,000 hours of annual aircraft delay in 2003 without further improvements, 14 have 15 percent or more GA operations and five of these have 25 percent or more GA operations.[2]

2. Based on Terminal Area Forecasts FY 1993–2005, FAA-APO-93-9, July 1993, operations data for 1991.

6.4.4 Conversion of Closing Military Airfields and Joint Use of Military Airfields

As one part of its overall strategy to enhance aviation system capacity, the FAA is pursuing a series of initiatives with the Department of Defense and state and local governments for the implementation of joint civilian and military use of existing military airfields and the conversion of closing military facilities to civilian use.

Commercial service airports, particularly in large metropolitan areas, are experiencing congestion and delays on the airfield, in the terminals, and in ground access to the airport itself. In many cases, airport sponsors are unable to expand to develop the additional facilities needed to continue to provide quality service to air travelers and the airlines. Without additional capacity, the increasing aircraft operations and passenger growth forecast for the future will result in greater delays, more costly operations, and less efficient passenger service. In addition, airfield pavement designs will require capacity improvements and strengthening to accommodate the increasing number of larger, heavier aircraft in the air carrier and general aviation fleet. System planning studies have been conducted by many metropolitan areas and state planning organizations in attempts to identify new sites for the construction of new airports or for capacity development at existing airports.

As one part of its overall strategy to enhance aviation system capacity, the FAA is pursuing a series of initiatives with the Department of Defense and state and local governments for the implementation of joint civilian and military use of existing military airfields and the conversion of closing military facilities to civilian use.

Historically, the development of new airports and the construction of new runways and runway extensions at existing airports has offered the greatest potential for increasing aviation system capacity. These options for achieving major capacity increases are becoming more difficult due to surrounding community development, environmental concerns, shortage of available adjacent property and funding required, lack of public support, rival commercial and residential interests, and other competing requirements.

Within the past ten years, airport system planning and local governmental efforts have been successful in leading to the construction of only one major new commercial service airport, the new Denver International Airport. Other studies, in San Diego, Orange County south of Los Angeles, Seattle, Chicago, New York, Boston, and Miami, for example, have not resulted in identifying new airport sites or, very often, in developing support for major expansion of the existing air carrier airports.

Recent changes in the world's political and military situation, combined with efforts to reduce the Nation's deficit, have

resulted in plans to close a number of military airfields and provided a one-time opportunity for State and local governments. Conversion of these military airfields into civil airports would provide significant aviation capacity gains with relatively small additional investments by the State and local governments. Most of these military airfields are designed to accommodate heavy wide-body aircraft and already have the 8,000 to 13,000 foot runway lengths necessary to support long-haul operations.

Currently, 36 major military airfields have become available for use as civil airports as a result of the Department of Defense (DOD) 1988, 1991, and 1993 military base closures. In addition, several large parcels of military property adjacent to other civil airports have become available for expansion of these airports. If the airfield or other portions of the bases are not conveyed for public use, the military proposes to sell these areas and use the proceeds to assist them in the realignment and closure of other facilities. Table 6-2 provides a listing of the potential civil role of closing military airfields, and Figure 6-1 shows the location of these closing military airfields.

Many of these airfields are conveniently located in the vicinity of congested metropolitan areas where the search for major new airports has been underway for years. Examples include: the Miami area where Homestead Air Force Base (AFB) has become available; Orange County, California, in which El Toro Marine Corps Air Station (MCAS) is located; Bergstrom AFB near Austin Texas, where the City had previously been planning to replace the Robert Mueller Municipal Airport with a new airport; Williams AFB near Phoenix; Pease AFB located 60 miles north of Boston Logan, where it could provide service to the metropolitan area north of Boston; and Norton AFB near San Bernardino in the Los Angeles area. Some of the smaller military airfields available for conversion are ideal for use as reliever airports relieving small/slow aircraft operations from the nearby commercial airports serving scheduled air carrier operations.

It is anticipated that about two thirds of the 36 airfields have the potential to become general aviation reliever airports initially, and, in the longer term, about one-half of these airports will continue to develop and become commercial service airports. Many of the remaining airfields will become general aviation airports, with several of the more rural airfields converted to other than airport purposes.

In addition to military airfield conversions to civil airports, there are about 21 military airfields now in operation accommodating joint civil and military use. For the most part, these joint-use airfields provide primary service to the communities

and have a modest impact on system capacity. For example, in South Carolina, Charleston AFB provides primary commercial service for Charleston. Similarly, Myrtle Beach AFB, which is currently being transitioned to the Myrtle Beach Jetport, previously provided primary commercial air service through joint use to a community that might not otherwise have had air carrier access to the commercial system. Also, Dillingham Army Airfield (AAF), Hawaii, and Rickenbacker Air National Guard (ANG) Base, Columbus, Ohio, provide congestion relief to the airports at Honolulu International and Port Columbus International Airports respectively.

Table 6-2. Potential Civil Role of Closing Military Airfields

State	Airfield	Airfield ID*	Closure List	Closure Date	Community	Near-Term Role**
Alaska	Adak NAS	NUW	93	Aug 94	Adak Island	GA
Arizona	Williams AFB	IWA	91	30 Sep 93	Phoenix	RL
Arkansas	Eaker AFB	BYH	91	15 Dec 92	Blytheville	GA
California	Alameda NAS	NGZ	93	Sep 97	Oakland	RL
	Castle AFB	MER	91	30 Sep 95	Merced	GA
	El Toro MCAS	NZJ	93	Sep 97	Orange County	RL/CM
	Fritzsche AAF	OAR	91	Sep 95	Monterey	RL
	George AFB	VCV	88	15 Dec 92	Victorville	GA/CM
	Hamilton AAF	SRF	88	Apr 93	San Francisco	RL
	March AFB	RIV	93	31 Mar 96	Riverside	RL
	Mather AFB	MHR	88	30 Sep 93	Sacramento	RL
	Moffett NAS	NUQ	91	Jul 94	San Jose	(NASA/USN)
	Norton AFB †	SBD	91	31 Mar 94	San Bernardino	RL/CM
	Tustin MCAS	NTK	91	Jul 97	Orange County	RL
Florida	Cecil Field NAS	NZC	93	Oct 96	Jacksonville	RL/GA
	Homestead AFB	HST	93	31 Mar 94	Miami	RL/GA
	MacDill AFB	MCF	91	31 Mar 94	Tampa	(NOAA/USAF)
Guam	Agana NAS †	NGM	93	Apr 98	Guam	Guam Int'l
Hawaii	Barbers Point NAS	NAX	93	Sep 97	Honolulu	RL
Illinois	Chanute AFB		88	30 Sep 93	Rantoul	RL/GA
	Glenview NAS	NBU	93	Sep 95	Chicago	GA
	O'Hare AF Reserve	ORD	93	30 Sep 97	Chicago	O'Hare Int'l
Indiana	Grissom AFB	GUS	91	30 Sep 94	Peru	GA
Louisiana	England AFB	AEX	91	15 Dec 92	Alexandria	GA/PR
Maine	Loring AFB	LIZ	91	30 Sep 94	Limestone	
Maryland	Tipton AAF	FME	88	Apr 95	Baltimore/D.C.	RL
Massachusetts	Moore AAF	AYE	91	Sep 95	Boston	RL/CM/PR
Michigan	Detroit NAF	MTC	93	Sep 94	Detroit	(Selfridge AF Reserve)
	K.I. Sawyer AFB	SAW	93	30 Sep 95	Marquette	GA/CM
	Wurtsmith AFB	OSC	91	30 Jun 93	Oscoda	GA
Midway Island	Midway NAF	NQM	93	Oct 93	Midway Island	
Missouri	Richards-Gebaur	GVW	91	30 Sep 94	Kansas City	RL
New Hampshire	Pease AFB †	PSM	88	31 Mar 91	Portsmouth/Boston	Pease Int'l Trade Port
New York	Griffiss AFB	RME	93	30 Sep 95	Rome	GA
	Plattsburgh AFB	PBG	93	30 Sep 95	Plattsburgh	GA
Ohio	Rickenbacker ANG	LCK	91	30 Sep 94	Columbus	RL
Pennsylvania	Warminster NADC	NJP	91	Mar 96	Philadelphia	RL
South Carolina	Myrtle Beach AFB †	MYR	91	31 Mar 93	Myrtle Beach	Myrtle Beach Jetport
Tennessee	Memphis NAS	NQA	93	Oct 95	Memphis	RL
Texas	Bergstrom AFB	BSM	91	30 Sep 93	Austin	PR
	Dallas NAS	NBE	93	Oct 95	Dallas	GA
	Carswell AFB	FWH	91	30 Sep 93	Fort Worth	(USN/AF Reserve)
	Chase NAS	NIR	91	30 Sep 92	Corpus Christi	GA

* The airfield identifiers have been used in Figure 6–1 to indicate the location of these airfields.

** Airport roles: PR = Primary CM = Commercial RL = Reliever GA = General Aviation

† Military Airport Program (MAP) recipient

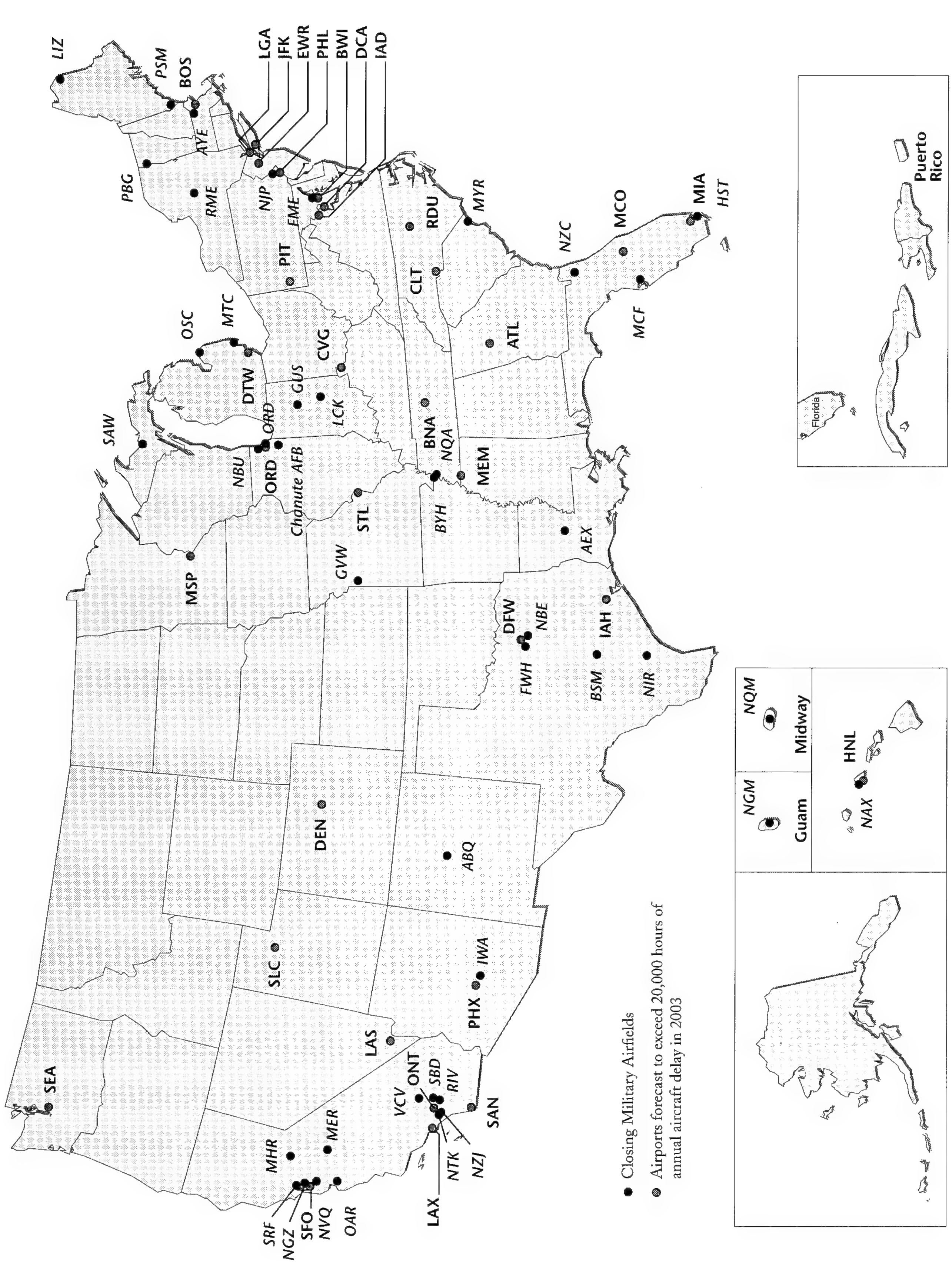


Figure 6-1. Location of Closing Military Airfields in Relation to Airports Forecast to Exceed 20,000 Hours of Delay in 2003

The most important first step in converting a closing military airfield or setting up a joint-use facility is to establish the State or local government sponsorship for the proposed civil aviation operation.

To assist in transitioning military airfields to civilian airports, the Military Airport Program (MAP), established as a funding set aside under the Airport Improvement Program (AIP), provides grant funding of airport master planning and capital development. The MAP allows the Secretary of Transportation to designate current or former military airfields for participation in the program. To participate, eligible airport sponsors apply to the FAA. In determining whether or not to designate a facility, the FAA will consider: (1) proximity to major metropolitan air carrier airports with current or projected high levels of delay; (2) capacity of existing airspace and traffic flow patterns in the metropolitan area; (3) the availability of local sponsors for civil development; (4) existing levels of operation; (5) existing facilities; and (6) any other appropriate factors.

Twelve current or former military airports have been designated thus far to participate in the MAP. These are: Stewart International Airport near Newburgh, New York; Ellington Field at Houston, Texas; Albuquerque International Airport, New Mexico; Scott Air Force Base, in Illinois; Myrtle Beach Air Force Base, in South Carolina; Agana International Airport, Guam; Manchester Municipal Airport, New Hampshire; Lincoln Municipal Airport, Nebraska; Lardo International Airport, Texas; Smyrna Airport, Tennessee; San Bernardino International Airport, California; and Pease International Trade Port, New Hampshire. Under the MAP, airports will receive funding for airport capital development, including rehabilitating airport pavements, terminals, lighting systems, improving access roads, automobile parking facilities, airport master plan studies, and other eligible projects necessary to convert a military airfield to an active civil airport.

The most important first step in converting a closing military airfield or setting up a joint-use facility is to establish the State or local government sponsorship for the proposed civil aviation operation. The conversion or joint use of military airfields is not a panacea for aviation system capacity problems, but it is an important component in the strategy of the State and local governments and the FAA to maximize the safe utilization of the Nation's aviation system.

6.4.5 Developing a Regional Airport System

The ultimate challenge for many delay-problem airports in the country in their efforts to implement capacity-enhancing improvements is the availability and expense of additional land. With no room to build independent parallel runways or new taxiways, commercial cargo and maintenance facilities, access roads, or parking facilities, an airport is faced with steadily increasing delays and severe constraints on growth in air traffic. Taking into account the characteristics of the market involved, airport authorities with delay-problem airports may need to look to development of a regional airport system.

In a regional airport system, various airports are identified to serve different roles and functions within the region. For example, one airport in the region may handle all or most of the international and long-haul traffic, while other airports handle the domestic and short-haul demand.

There are variations of a regional airport system in use in many of the major metropolitan areas, including New York, Chicago, Dallas-Fort Worth, Houston, Los Angeles, San Francisco, and Washington, D.C. This same concept has also been suggested in Boston and Seattle, with each proposing to introduce limited air carrier or commuter service at another airport in the area, Laurence G. Hanscom Field in Bedford, MA, and Snohomish County Paine Field in Everett, WA.

One study in Massachusetts demonstrated that development of scheduled air carrier service at the existing Hanscom Airport could be almost as effective as building a new airport in terms of relieving Boston-Logan. However, there is strong local opposition to this initiative, and consequently, there are no current proposals to develop scheduled, air carrier service at Hanscom. Current efforts are focusing instead on measures to enhance the role of existing air carrier airports servicing the outlying portions of the Logan market. Since the State has abandoned efforts to land bank a site for a new air carrier airport, creating a more effective regional airport system is critical to meeting the future forecasted need for air travel in the greater Boston market area.

6.5 Demand Management

The anticipated outcome of peak-hour pricing is an increase in the average number of passengers per flight through the use of larger aircraft and a decrease in general aviation and small commuter aircraft operations when demand is highest.

Slot allocations will only be able to reduce delay by effectively "capping" the total number of operations at the airport.

Generally, demand management attempts to make more efficient use of existing airport capacity by increasing the average number of passengers per aircraft operation and by making better use of under-utilized capacity in off-peak periods. Two methods of demand management are peak-hour pricing and slot allocation.

Peak-hour pricing attempts to operate through market forces by increasing the price of using an airport when demand is highest. Peak-hour pricing is not meant to encourage the transfer of air carrier passenger flights to off-peak hours (the price differential required to induce a plane load of passengers to travel off peak would be tremendous), but rather to provide an economic disincentive for smaller aircraft (without creating any outright restriction) to using air carrier runways during critical peak hours. The anticipated outcome of peak-hour pricing is an increase in the average number of passengers per flight through the use of larger aircraft and a decrease in general aviation and small commuter aircraft operations when demand is highest.

To redistribute air carrier passenger flights, it is generally more practical to use slot allocations rather than pricing mechanisms. However, as operations increase, there may not be enough extra capacity in the traditional off-peak time periods to accommodate additional operations without significant delays. At this point, slot allocations will only be able to reduce delay by effectively "capping" the total number of operations at the airport. This program can be cumbersome to execute both equitably and efficiently. Its use within this country has been restricted to the four high density traffic airports, Washington National, Chicago O'Hare, New York LaGuardia, and New York Kennedy, where delays have historically affected the performance of the National Airspace System (NAS).

While programs to redistribute demand may be less expensive to the airport owner than physical improvements, any actions that significantly raise the cost of air travel or limit the ability of the airlines to offer air service in response to passenger demand can have far-reaching implications on the region's economy. Air travel is not an economic product in itself, but a utility used for other purposes, e.g., business or pleasure. When the cost of this utility increases, or its efficiency diminishes, those economic activities that depend on air travel will be negatively affected. Therefore, any analysis of demand management strategies has to carefully consider these impacts prior to its implementation.

Proponents of demand management cite concern for the economic inequities imposed by congested facilities. During periods of congestion, each additional flight creates delays in all other competing flights that far exceed the delay cost experienced by the passengers and airline from that one additional flight. Due to these "externalities," the rational behavior of each airline in scheduling additional flights is in conflict with the collective interests of all users. Under these circumstances, demand management is viewed as necessary to maintain reasonable levels of cost and service at an airport. Demand management initiatives can also provide relief in a more timely manner than physical facility improvements. In that regard, they may be a useful "bridge" if, in the future, air travel demand increases at a rate that overwhelms the airport's ability to provide the requisite facilities.

The critical question is whether the premium prices that result directly or indirectly from demand management are sufficiently offset by savings in the costs associated with delay and congestion. The answer to this deceivingly simple question is usually quite complex and further complicated by the issue of who pays and who benefits.

6.6 Intermodalism

Aviation is a part of the national transportation system. Each mode of transportation within the system has specific strengths and weaknesses. The transportation system cannot work effectively if critical segments are not connected. No matter how good the individual parts of the system may be, the effectiveness of the overall system depends on the connections a passenger or consignment of cargo can make in getting from origin to destination.

The effectiveness of the overall transportation system depends on the connections a passenger or consignment of cargo can make in getting from origin to destination.

Intermodalism is a goal fostered under National Transportation Policy and the Intermodal Surface Transportation Efficiency Act enacted in 1991. Its purpose is to improve the speed, reliability, and cost effectiveness of the country's overall transportation system. One initial objective should be to devise an integrated transportation strategy to promote intermodal exchanges among highway, railway, waterway, and air transportation. Intermodalism is not intended to bypass the airports but to bring passengers to and from the airport and their point of origin and destination.

In the past, the emphasis at most airports has been on ground access for passengers via roads and highways. Airport planning studies should begin to investigate the feasibility of subway or train stations on the airport with easy access to pas-

senger terminals and of cargo-handling facilities that enable quick, easy transfer among trucks, trains, and airplanes.

6.7 High-Speed Rail

High-speed rail is ideally suited for short-haul intercity trips and as a feeder for major hub airports, especially in the future when new airports may have to be built in outlying locations. These high-speed trains could replace many of the short-haul and feeder flights that add to the congestion and delay at the major hub airports.

High-speed passenger trains, which will reach speeds of 150 to 200 miles per hour, have been recommended or are being studied for use in several densely populated intercity transportation corridors, for example, Washington-Philadelphia-New York-Boston in the Northeast; Portland-Seattle-Vancouver in the Pacific Northwest; and Dallas-Fort Worth-Houston-San Antonio in Texas. Figure 6-2 illustrates these and several other examples of high-speed rail corridors that have been tentatively proposed. High-speed rail appears to be a reasonable transportation alternative, especially for densely populated urban corridors and distances of less than 450 miles, that would serve to reduce airport congestion at many delay-problem airports.

On the one hand, high-speed rail represents another competitive force for short-haul air traffic and can be seen as a threat to air carrier markets for trips shorter than 500 miles. Commercial air already provides a rapid intercity mass transportation system. On the other hand, high-speed rail is ideally suited for short-haul intercity trips and as a feeder for major hub airports, especially in the future when new airports may have to be built in outlying locations. These high-speed trains could replace many of the short-haul and feeder flights that add to the congestion and delay at the major hub airports. In fact, the airlines themselves may be partners in operating such trains, much like in Europe. Intercity high-speed rail systems would be designed for immediate access to the airport, with rail stations "inside" passenger terminals. In large metropolitan areas, high-speed rail could also provide the connection among multiple airports serving the region, carrying passengers during the peak-hours of the day and perhaps carrying cargo to and from the airports during the off-peak hours at night.

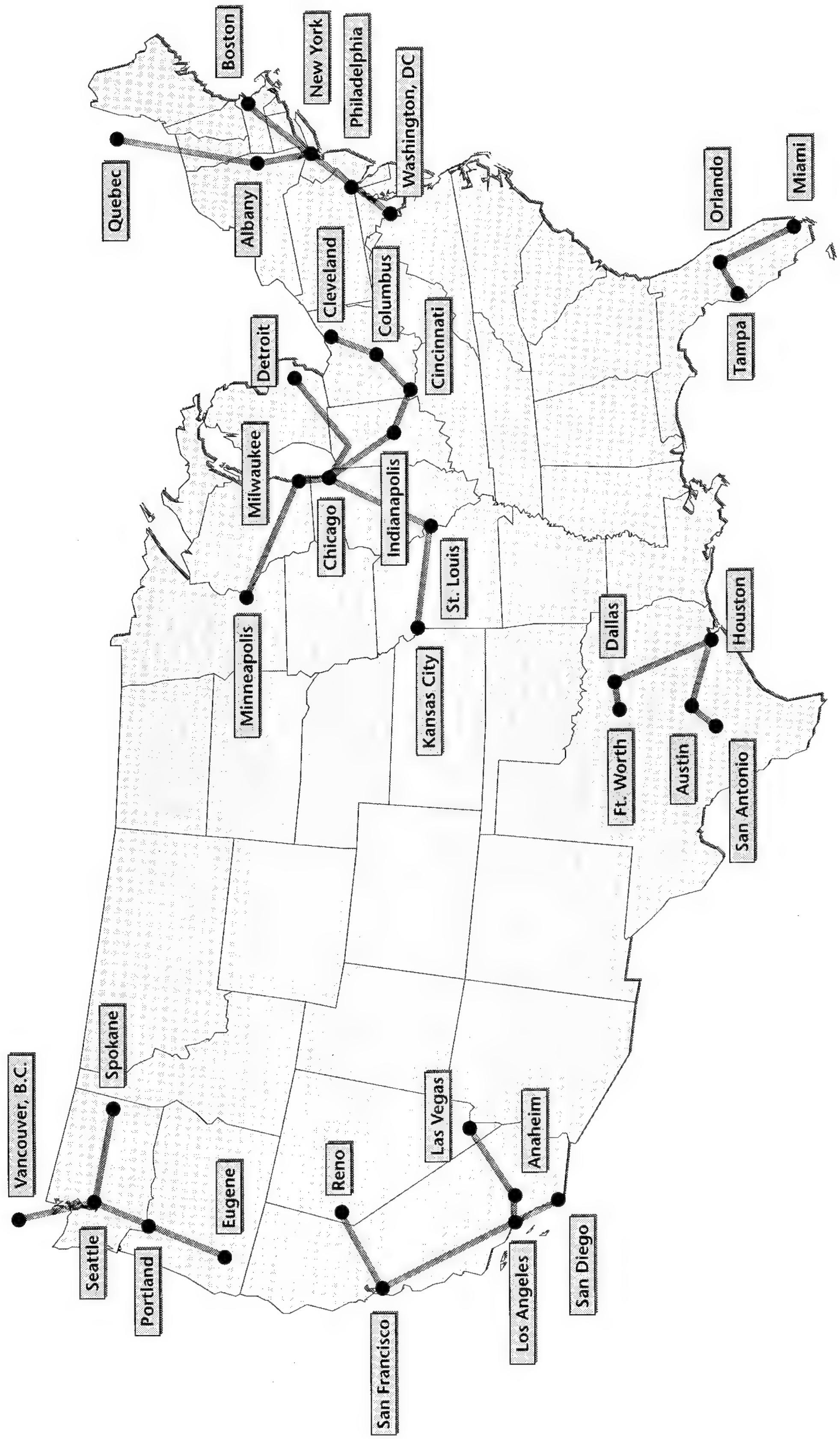


Figure 6-2. Intercity Corridors Tentatively Proposed for High-Speed Rail

6.8 Telecommunications

Recent advances in telecommunications are often promoted as alternatives to business travel.

These new technologies may also indirectly stimulate additional demand for business travel.

Recent advances in telecommunications are often promoted as alternatives to business travel that can save money, facilitate rapid response, improve customer service, increase productivity, and be as effective, or nearly as effective, as being there in person. Video teleconferencing, facsimile, electronic data interchange, high-speed networks, and other developments in telecommunications could affect the demand for passenger, overnight package, and cargo air transportation services, particularly as these new technologies mature, improve in quality, and become more cost-effective.

According to a recent report,[3] most of the studies that have analyzed the effects of these recent innovations in telecommunications have examined only the direct, negative impact the new technologies may have in substituting for certain types of business travel. The report points out that, although difficult to quantify now, it is reasonable to suggest that these new technologies may also indirectly stimulate additional demand for business travel. As workers become more productive and companies more efficient, "cost savings and productivity gains will enable a significantly higher number of companies to sell their products and services in areas not targeted before due to higher operating costs."

3. *making connections: how telecommunications technologies will affect business and leisure air travel*, prepared for the Federal Aviation Administration, Office of Aviation Policy, Plans, and Management Analysis, by Apogee Research, Inc., February 1994.

Chapter 7

Summary

The Aviation Capacity Enhancement Plan is intended to be a comprehensive "ground-up" view of aviation system requirements and development, starting at the airport level and extending to terminal airspace, en route airspace, and airspace and traffic flow management. The first step in this problem-solving exercise is problem definition.

This plan defines the capacity problem in terms of flight delays, rather than dealing with a more abstract "definition of capacity." While it is relatively simple to compute an airport's hourly throughput capacity (the number of flight operations which can be handled under IFR or VFR for a given runway operating configuration), that throughput can change each hour as weather, aircraft fleet mix, and runway configurations change. Annualizing airport capacity is thus a difficult task.

In 1993, 23 of the top 100 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports which could exceed 20,000 hours of annual aircraft delay in the year 2003 is projected to grow from 23 to 32.

While it is common for demand to exceed hourly capacity at some airports, there are ways of accommodating that demand. For example, air traffic management can regulate departures and slow down en route traffic, so flights are shifted into times of less congestion. However, this is only a temporary solution, because, as traffic increases at a given airport, there will be fewer off-peak hours into which flights might be shifted.

There are several techniques under investigation to manage demand at delay-problem airports. One is to improve the reliever and general aviation (GA) airport system so that small aircraft prefer to use them. There could be significant reduction in flight delays if a percentage of small/slow aircraft operations shifted to reliever airports. However, some of the forecast delay-problem airports have a low percentage of small aircraft operations. Those airports are largely "relieved," and a further reduction in the operations of small/slow aircraft would be of marginal significance in the reduction of flight delays.

Having first identified forecast delay-problem airports, this plan next attempts to document planned or technologically feasible capacity development at those airports. The FAA co-sponsors airport capacity design team studies at major airports to

assess how airport development and new technology could "optimize" capacity on a site-specific basis. Airport capacity design team studies have been completed at Albuquerque, Atlanta, Boston, Charlotte, Chicago, Cleveland, Columbus, Detroit, Fort Lauderdale-Hollywood, Honolulu, Houston Intercontinental, Indianapolis, Kansas City, Los Angeles, Memphis, Miami, Minneapolis-Saint Paul, Nashville, New Orleans, Newport News/Williamsburg, Norfolk, Oakland, Orlando, Philadelphia, Phoenix, Pittsburgh, Raleigh-Durham, Richmond, St. Louis, Salt Lake City, San Antonio, San Francisco, San Jose, San Juan, Seattle-Tacoma, and Washington Dulles.

Moving from "the ground up," this plan identifies new terminal airspace procedures which will increase capacity for existing or new runway configurations. Of the top 100 airports, 9 could benefit from independent parallel approaches using the Final Monitor Aid (FMA) with current radar systems, 4 could benefit from independent parallel approaches to triple and quadruple runways using current radar systems, 13 could benefit from simultaneous operations on wet intersecting runways, 45 could benefit from improved operations on parallel runways separated by less than 2,500 feet, 9 could benefit from dependent approaches to three parallel runways, and 38 could benefit from independent converging approaches . Demonstration programs have been completed or are underway for these new approach procedures.

Some of the new approach procedures and airport capacity projects require new technology and new systems and equipment. This plan outlines the progress of FAA RE&D and F&E programs currently under way to provide that new technology.

Many of the technology programs are designed to reduce the capacity differential between IFR and VFR operations. Delays attributable to weather (resulting in large part from the difference in VFR and IFR separation standards) accounted for 72 percent of all flights delayed 15 minutes or more in 1993. Significant gains in capacity may be achieved with the use of new electronic guidance and control equipment if two or three flight arrival streams can be maintained in IFR, rather than being reduced to one or two arrival streams. These programs are the Precision Runway Monitor (PRM), Converging Runway Display Aid (CRDA), Triple and Quadruple Instrument Approaches, and Global Positioning System (GPS).

Some of the new technology programs are designed to provide more information to air traffic controllers, such as the Center-TRACON Automation System (CTAS), or to pilots, such as the Traffic Alert Collision and Avoidance System (TCAS), with improved visual displays and non-voice communications.

Those programs may not show as large an increase in capacity as those programs providing multiple flight arrival and departure streams, but they are significant nonetheless.

Some of the technology programs are designed to improve the efficiency of aircraft movement on the airport surface. The Airport Surface Traffic Automation (ASTA) program, for example, will expedite surface movement while reducing the number of runway incursions.

Some of the technology programs are computer simulation tools to help in airfield and airspace analysis. For example, the Airport and Airspace Simulation Model (SIMMOD), National Airspace Performance Analysis Capability (NASPAC), Sector Design Analysis Tool (SDAT), and Terminal Airspace Visualization Tool (TAVT) will help in the evaluation of various alternatives. Some technology programs are designed to "optimize" the aviation system through better planning and improved prediction capability in a laboratory environment such as the National Simulation Capability (NSC).

The "ground up" view encompasses en route airspace. This plan outlines programs designed to increase en route airspace capacity, including Automated En Route Air Traffic Control (AERA), Advanced Traffic Management System (ATMS), Automatic Dependent Surveillance (ADS), and Oceanic Display and Planning System (ODAPS).

Airspace capacity design team projects have been established to analyze and optimize airspace procedures. Projects have been accomplished in Los Angeles, Dallas-Ft. Worth, Chicago, Kansas City, Houston/Austin, Oakland, New York, Jacksonville, Miami, and Atlanta. Results summaries are included in this plan.

From a "ground up" view, after optimizing existing airport capacity, terminal airspace procedures, and en route airspace capacity using new technology, the next level is adding "reliever" airports and "supplemental" airports for additional aviation system capacity. "Supplemental" airports are existing commercial service airports that could act as reliever airports for delay-problem airports. The FAA is also pursuing initiatives for the joint civilian and military use of current military airfields and the conversion of former military air bases to civilian use for capacity enhancement to the overall aviation system.

The largest capacity gains come from building new airports and new or extended runways at existing airports. One such project is the construction of a new international airport at Denver. Construction began in late 1989. The initial phase will consist of five runways, and is scheduled to open in 1995. In 1992, Colorado Springs completed construction of a new par-

allel runway, and Nashville and Washington Dulles completed runway extensions. In 1993, Detroit Metropolitan Wayne County completed construction of a new parallel runway, and runway extensions were completed at Dallas-Fort Worth, San Jose, Kailua-Kono Keahole, and Islip Long Island Mac Arthur. In 1993, Salt Lake City and Memphis began construction of independent parallel runways, and Louisville Standiford Field began construction of two independent parallel runways. In 1994, Kansas City should complete construction of a new independent parallel runway.

Of the top 100 airports, 60 have proposed new runways or extensions to existing runways. Of the 23 delay-problem airports in 1993, 15 are in the process of constructing or planning the construction of new runways or extensions to existing runways. Of the 32 delay-problem airports forecast for the year 2003, 24 propose to build new runways or runway extensions. The total anticipated cost of completing these new runways and runway extensions exceeds $9.0 billion.

While much has been done and more is planned to increase system-wide capacity, it should be noted that the FAA's resources are limited. The demand for Facilities and Equipment (F&E) and Airport Improvement Program (AIP) funds far exceeds availability. However, the FAA will continue to explore innovative methods of increasing system capacity.

System capacity must continue to grow in order to enable the air transportation industry to maintain the same level of service quality and allow airline competition to continue. In the dozen years since airline deregulation, real air fares have declined. Both the quality and cost of air service are strongly tied to aviation system capacity and will continue to show favorable trends only if aviation system capacity continues to grow to meet demand.

1994 ACE PLAN

Aviation Capacity Enhancement

Appendices

Appendix A

Aviation Statistics

Table A-1. Airport Operations and Enplanements, 1991 and 1992[1]

City-Airport	Airport ID	Rank	Enplanements FY91	Enplanements FY92	Operations FY91	Operations FY92	Operations FY93
Chicago O'Hare Int'l	ORD	1	27,827,241	29,986,963	808,759	838,093	851,865
Dallas-Fort Worth Int'l	DFW	2	24,092,801	25,963,239	731,070	763,372	789,183
Los Angeles Int'l	LAX	3	22,519,698	22,911,585	660,680	678,398	681,845
William B. Hartsfield Atlanta Int'l	ATL	4	18,886,533	20,966,165	639,698	611,889	655,640
San Francisco Int'l	SFO	5	15,186,626	15,257,138	435,309	424,829	423,404
Denver Stapleton Int'l	DEN	6	13,270,540	14,476,601	491,275	499,001	552,238
New York John F. Kennedy Int'l	JFK	7	12,577,222	13,363,580	304,315	328,528	351,205
Miami Int'l	MIA	8	12,492,320	12,587,255	481,709	486,222	527,545
Newark Int'l	EWR	9	11,050,061	11,967,280	381,850	403,978	431,944
Detroit Metropolitan Wayne County	DTW	10	10,354,655	10,986,668	390,863	413,544	460,009
Phoenix Sky Harbor Int'l	PHX	11	11,111,486	10,958,400	499,157	487,615	520,403
Boston Logan Int'l	BOS	12	10,338,977	10,641,027	440,715	482,582	495,347
Minneapolis-St. Paul Int'l	MSP	13	9,770,403	10,639,045	382,856	404,243	442,341
Lambert St. Louis Int'l	STL	14	9,621,236	10,476,785	412,539	429,473	441,142
Honolulu Int'l	HNL	15	10,113,891	10,220,760	393,709	413,725	365,195
Las Vegas McCarran Int'l	LAS	16	9,653,154	10,038,181	398,637	407,668	440,393
Orlando Int'l	MCO	17	8,839,819	9,989,092	275,157	294,387	327,199
New York LaGuardia	LGA	18	9,788,285	9,751,311	332,930	337,279	335,071
Greater Pittsburgh Int'l	PIT	19	8,343,024	9,350,221	386,260	421,903	419,581
Charlotte/Douglas Int'l	CLT	20	8,425,447	9,099,577	440,956	466,351	446,315
Houston Intercontinental	IAH	21	8,452,340	8,977,522	310,404	320,234	352,340
Seattle-Tacoma Int'l	SEA	22	7,934,250	8,773,365	340,411	346,180	339,968
Philadelphia Int'l	PHL	23	7,423,013	7,850,375	382,646	377,033	390,736
Washington National	DCA	24	7,219,161	7,331,346	297,559	312,014	315,912
Salt Lake City Int'l	SLC	25	5,800,044	6,510,001	301,755	316,783	324,595
San Diego Int'l Lindberg Field	SAN	26	5,617,219	5,923,072	206,424	214,844	209,267
Greater Cincinnati Int'l	CVG	27	5,044,813	5,780,241	297,963	304,214	306,811
Washington Dulles Int'l	IAD	28	5,407,070	5,308,389	267,007	287,111	277,483
Nashville Int'l	BNA	29	4,300,568	5,068,011	274,139	302,030	318,886
Raleigh-Durham Int'l	RDU	30	4,640,334	4,939,336	270,534	289,462	294,006
Tampa Int'l	TPA	31	4,748,930	4,793,304	233,650	229,470	240,425
Baltimore-Washington Int'l	BWI	32	4,966,257	4,370,829	282,320	265,844	261,674
Cleveland Hopkins Int'l	CLE	33	3,885,103	4,266,092	244,626	237,216	247,502
San Juan Luis Muñoz Marín Int'l	SJU	34	4,012,422	4,192,629	200,292	205,560	180,749
Ft. Lauderdale-Hollywood Int'l	FLL	35	3,960,913	4,109,796	209,752	204,183	217,786
Houston William P. Hobby	HOU	36	3,781,702	4,008,376	267,199	242,999	239,634
Memphis Int'l	MEM	37	3,932,939	3,958,432	321,814	344,655	337,608
San Jose Int'l	SJC	38	3,443,484	3,775,332	336,928	342,918	312,399
Kansas City Int'l	MCI	39	3,482,600	3,697,821	168,193	176,754	184,848
Portland Int'l	PDX	40	3,178,617	3,589,361	264,854	269,445	280,263
New Orleans Int'l	MSY	41	3,255,817	3,340,961	152,126	137,373	141,384
Metropolitan Oakland Int'l	OAK	42	3,013,384	3,186,437	413,916	419,233	439,214
Indianapolis Int'l	IND	43	2,925,853	3,139,728	234,045	247,553	238,789

1. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts.*

Table A-1. Airport Operations and Enplanements, 1991 and 1992[1]

City-Airport	Airport ID	Rank	Enplanements FY91	Enplanements FY92	Operations FY91	Operations FY92	Operations FY93
Ontario Int'l	ONT	44	2,872,927	3,042,508	156,306	152,935	152,914
Dallas-Love Field	DAL	45	2,794,424	2,944,942	208,015	212,049	212,854
Santa Ana John Wayne	SNA	46	2,636,331	2,769,936	550,602	557,442	494,378
San Antonio Int'l	SAT	47	2,597,869	2,730,976	213,910	210,063	219,305
Albuquerque Int'l	ABQ	48	2,458,353	2,626,486	211,561	211,601	209,567
Sacramento Metropolitan	SMF	49	2,175,686	2,552,734	152,161	162,995	169,272
Palm Beach Int'l	PBI	50	2,524,206	2,514,095	223,775	225,784	230,903
Kahului	OGG	51	2,167,932	2,385,649	181,780	179,808	173,002
Port Columbus Int'l	CMH	52	1,698,021	2,358,521	213,723	224,598	217,049
Bradley Int'l	BDL	53	2,232,166	2,297,791	171,063	175,109	166,859
Austin Robert Mueller Municipal	AUS	54	2,051,531	2,169,135	182,831	186,796	188,026
Milwaukee General Mitchell Int'l	MKE	55	2,043,068	2,157,169	205,587	202,286	198,529
Chicago Midway	MDW	56	3,241,851	2,029,124	301,690	184,000	189,755
Burbank-Glendale-Pasadena	BUR	57	1,843,247	1,913,912	229,492	214,361	207,460
Reno Cannon Int'l	RNO	58	1,676,197	1,895,183	160,107	161,839	162,441
El Paso Int'l	ELP	59	1,671,354	1,702,205	164,300	159,710	151,284
Fort Myers SW Florida Regional	RSW	60	1,708,824	1,692,442	66,631	62,578	66,004
Anchorage Int'l	ANC	61	1,592,094	1,691,428	228,432	236,719	218,279
Greater Buffalo Int'l	BUF	62	1,631,868	1,628,534	128,205	136,043	142,136
Oklahoma City Will Rogers World	OKC	63	1,482,882	1,543,566	148,712	163,336	142,492
Tulsa Int'l	TUL	64	1,420,331	1,459,526	187,830	196,835	188,009
Jacksonville Int'l	JAX	65	1,277,495	1,333,935	155,234	146,436	129,683
Tucson Int'l	TUS	66	1,218,426	1,254,597	234,872	235,309	228,877
Norfolk Int'l	ORF	67	1,266,060	1,251,548	142,742	138,084	134,564
Guam Agana Field	NGM	68	1,112,628	1,233,022	—	—	69,362
Greater Rochester Int'l	ROC	69	1,160,582	1,159,306	182,613	194,764	188,072
Providence Green State	PVD	70	1,108,383	1,120,491	151,994	146,937	125,442
Syracuse Hancock Int'l	SYR	71	1,186,994	1,120,011	182,216	176,567	180,936
Lihue	LIH	72	1,259,368	1,111,730	109,903	123,105	55,194
Dayton Int'l	DAY	73	1,975,478	1,099,090	192,712	149,879	132,234
Omaha Eppley Airfield	OMA	74	1,104,414	1,085,448	164,008	155,058	143,739
Little Rock Adams Field	LIT	75	977,062	1,043,736	140,255	162,439	171,399
Louisville Standiford Field	SDF	76	1,001,745	1,036,889	158,050	156,083	155,941
Kailua-Kona Keahole	KOA	77	996,564	1,022,344	57,553	61,172	60,393
Albany County	ALB	78	976,174	1,011,344	156,448	162,225	160,587
Birmingham	BHM	79	967,754	981,171	184,707	175,986	168,074
Richmond Int'l	RIC	80	872,943	954,165	141,300	145,079	154,925
Greensboro Piedmont Triad Int'l	GSO	81	854,572	924,267	137,275	130,026	126,446
Spokane Int'l	GEG	82	797,892	922,609	111,912	124,506	122,360
Sarasota Bradenton	SRQ	83	923,212	882,365	173,740	161,749	152,722
Des Moines Int'l	DSM	84	718,927	715,587	144,952	139,135	128,797
Colorado Springs Municipal	COS	85	624,431	712,144	189,195	228,714	246,732
Hilo Int'l	ITO	86	667,847	703,736	89,252	89,284	91,903

1. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts.*

Table A-1. Airport Operations and Enplanements, 1991 and 1992[1]

City-Airport	Airport ID	Rank	Enplanements FY91	Enplanements FY92	Operations FY91	Operations FY92	Operations FY93
Grand Rapids Kent County Int'l	GRR	87	667,456	699,654	171,425	152,260	150,313
Harrisburg Int'l	MDT	88	598,095	663,456	101,744	95,916	86,427
Boise Air Terminal	BOI	89	585,031	647,554	152,746	161,434	155,166
Charleston AFB Int'l	CHS	90	640,775	645,762	131,444	135,599	114,427
Knoxville McGhee-Tyson	TYS	91	576,502	628,219	152,638	130,640	130,368
Wichita Mid-Continent	ICT	92	559,966	602,048	173,722	178,853	174,527
Charlotte Amalie St. Thomas (VI)	STT	93	602,373	583,817	107,563	108,796	105,217
Lubbock Int'l	LBB	94	564,603	583,156	122,130	113,035	103,112
Portland Int'l Jetport	PWM	95	550,953	569,775	111,834	117,121	126,353
Greer Greenville-Spartanburg	GSP	96	529,573	553,026	60,388	60,561	56,855
Islip Long Island Mac Arthur	ISP	97	556,599	550,762	224,691	202,008	195,198
Dane County Regional	MSN	98	469,644	549,723	136,093	140,890	141,946
Saipan Int'l	GSN	99	468,490	548,170	—	—	21,211
Midland Int'l	MAF	100	538,689	532,202	92,393	92,464	93,294

Totals:
- 1991 Enplanements 450,169,114
- 1992 Enplanements 473,664,350
- 1991 Operations 24,793,458
- 1992 Operations 25,095,189
- 1993 Operations 25,293,458

1. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-2. Airport Enplanements, 1992 and Forecast 2005[2]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY2005	% Growth
Chicago O'Hare Int'l	ORD	1	29,986,963	46,991,000	56.7
Dallas-Fort Worth Int'l	DFW	2	25,963,239	44,681,000	72.1
Los Angeles Int'l	LAX	3	22,911,585	32,262,000	40.8
William B. Hartsfield Atlanta Int'l	ATL	4	20,966,165	28,279,000	34.9
San Francisco Int'l	SFO	5	15,257,138	26,761,000	75.4
Denver Stapleton Int'l [3]	DEN	6	14,476,601	27,685,000	91.2
New York John F. Kennedy Int'l	JFK	7	13,363,580	18,512,000	38.5
Miami Int'l	MIA	8	12,587,255	20,001,000	58.9
Newark Int'l	EWR	9	11,967,280	20,786,000	73.7
Detroit Metropolitan Wayne County	DTW	10	10,986,668	18,949,000	72.5
Phoenix Sky Harbor Int'l	PHX	11	10,958,400	19,251,000	75.7
Boston Logan Int'l	BOS	12	10,641,027	17,129,000	61.0
Minneapolis-St. Paul Int'l	MSP	13	10,639,045	16,466,000	54.8
Lambert St. Louis Int'l	STL	14	10,476,785	18,300,000	74.7
Honolulu Int'l	HNL	15	10,220,760	13,986,000	36.8
Las Vegas McCarran Int'l	LAS	16	10,038,181	18,349,000	82.8
Orlando Int'l	MCO	17	9,989,092	16,545,000	65.6
New York LaGuardia	LGA	18	9,751,311	14,185,000	45.5
Greater Pittsburgh Int'l	PIT	19	9,350,221	15,563,000	66.4
Charlotte/Douglas Int'l	CLT	20	9,099,577	14,245,000	56.5
Houston Intercontinental	IAH	21	8,977,522	13,348,000	48.7
Seattle-Tacoma Int'l	SEA	22	8,773,365	13,916,000	58.6
Philadelphia Int'l	PHL	23	7,850,375	13,397,000	70.7
Washington National	DCA	24	7,331,346	8,774,000	19.7
Salt Lake City Int'l	SLC	25	6,510,001	9,881,000	51.8
San Diego Int'l Lindberg Field	SAN	26	5,923,072	10,445,000	76.3
Greater Cincinnati Int'l	CVG	27	5,780,241	12,256,000	112.0
Washington Dulles Int'l	IAD	28	5,308,389	10,871,000	104.8
Nashville Int'l	BNA	29	5,068,011	8,215,000	62.1
Raleigh-Durham Int'l	RDU	30	4,939,336	10,323,000	109.0
Tampa Int'l	TPA	31	4,793,304	9,059,000	89.0
Baltimore-Washington Int'l	BWI	32	4,370,829	7,258,000	66.1
Cleveland Hopkins Int'l	CLE	33	4,266,092	5,984,000	40.3
San Juan Luis Muñoz Marín Int'l	SJU	34	4,192,629	7,231,000	72.5
Ft. Lauderdale-Hollywood Int'l	FLL	35	4,109,796	8,131,000	97.8
Houston William P. Hobby	HOU	36	4,008,376	5,202,000	29.8
Memphis Int'l	MEM	37	3,958,432	7,311,000	84.7
San Jose Int'l	SJC	38	3,775,332	7,043,000	86.6
Kansas City Int'l	MCI	39	3,697,821	6,828,000	84.6
Portland Int'l	PDX	40	3,589,361	5,429,000	51.3
New Orleans Int'l	MSY	41	3,340,961	5,951,000	78.1
Metropolitan Oakland Int'l	OAK	42	3,186,437	4,379,000	37.4

2. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.
3. Assumes development of a new airport at Denver and increased hubbing activity in 1993–1995.

Table A-2. Airport Enplanements, 1992 and Forecast 2005[2]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY2005	% Growth
Indianapolis Int'l	IND	43	3,139,728	4,401,000	40.2
Ontario Int'l	ONT	44	3,042,508	9,069,000	198.1
Dallas-Love Field	DAL	45	2,944,942	4,434,000	50.6
Santa Ana John Wayne	SNA	46	2,769,936	4,903,000	77.0
San Antonio Int'l	SAT	47	2,730,976	3,879,000	42.0
Albuquerque Int'l	ABQ	48	2,626,486	4,261,000	62.2
Sacramento Metropolitan	SMF	49	2,552,734	5,036,000	97.3
Palm Beach Int'l	PBI	50	2,514,095	4,498,000	78.9
Kahului	OGG	51	2,385,649	3,399,000	42.5
Port Columbus Int'l	CMH	52	2,358,521	3,326,000	41.0
Bradley Int'l	BDL	53	2,297,791	3,820,000	66.2
Austin Robert Mueller Municipal	AUS	54	2,169,135	4,740,000	118.5
Milwaukee General Mitchell Int'l	MKE	55	2,157,169	4,367,000	102.4
Chicago Midway	MDW	56	2,029,124	3,287,000	62.0
Burbank-Glendale-Pasadena	BUR	57	1,913,912	2,553,000	33.4
Reno Cannon Int'l	RNO	58	1,895,183	2,820,000	48.8
El Paso Int'l	ELP	59	1,702,205	2,633,000	54.7
Fort Myers SW Florida Regional	RSW	60	1,692,442	3,086,000	82.3
Anchorage Int'l	ANC	61	1,691,428	2,538,000	50.1
Greater Buffalo Int'l	BUF	62	1,628,534	2,696,000	65.5
Oklahoma City Will Rogers World	OKC	63	1,543,566	2,833,000	83.5
Tulsa Int'l	TUL	64	1,459,526	2,278,000	56.1
Jacksonville Int'l	JAX	65	1,333,935	2,386,000	78.9
Tucson Int'l	TUS	66	1,254,597	2,458,000	95.9
Norfolk Int'l	ORF	67	1,251,548	2,161,000	72.7
Guam Agana Field	NGM	68	1,233,022	—	—
Greater Rochester Int'l	ROC	69	1,159,306	2,051,000	76.9
Providence Green State	PVD	70	1,120,491	1,495,000	33.4
Syracuse Hancock Int'l	SYR	71	1,120,011	1,960,000	75.0
Lihue	LIH	72	1,111,730	1,797,000	61.6
Dayton Int'l	DAY	73	1,099,090	2,415,000	119.7
Omaha Eppley Airfield	OMA	74	1,085,448	1,725,000	58.9
Little Rock Adams Field	LIT	75	1,043,736	1,604,000	53.7
Louisville Standiford Field	SDF	76	1,036,889	1,748,000	68.6
Kailua-Kona Keahole	KOA	77	1,022,344	1,771,000	73.2
Albany County	ALB	78	1,011,344	1,640,000	62.2
Birmingham	BHM	79	981,171	1,595,000	62.6
Richmond Int'l	RIC	80	954,165	1,684,000	76.5
Greensboro Piedmont Triad Int'l	GSO	81	924,267	1,462,000	58.2
Spokane Int'l	GEG	82	922,609	1,626,000	76.2
Sarasota Bradenton	SRQ	83	882,365	1,356,000	53.7
Des Moines Int'l	DSM	84	715,587	1,220,000	70.5
Colorado Springs Municipal	COS	85	712,144	1,256,000	76.4

2. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-2. Airport Enplanements, 1992 and Forecast 2005[2]

City-Airport	Airport ID	Rank	Enplanements FY92	Enplanements FY2005	% Growth
Hilo Int'l	ITO	86	703,736	1,009,000	43.4
Grand Rapids Kent County Int'l	GRR	87	699,654	1,089,000	55.6
Harrisburg Int'l	MDT	88	663,456	1,398,000	110.7
Boise Air Terminal	BOI	89	647,554	1,013,000	56.4
Charleston AFB Int'l	CHS	90	645,762	1,119,000	73.3
Knoxville McGhee-Tyson	TYS	91	628,219	1,042,000	65.9
Wichita Mid-Continent	ICT	92	602,048	1,096,000	82.0
Charlotte Amalie St. Thomas (VI)	STT	93	583,817	1,840,000	215.2
Lubbock Int'l	LBB	94	583,156	840,000	44.0
Portland Int'l Jetport	PWM	95	569,775	1,045,000	83.4
Greer Greenville-Spartanburg	GSP	96	553,026	809,000	46.3
Islip Long Island Mac Arthur	ISP	97	550,762	828,000	50.3
Dane County Regional	MSN	98	549,723	950,000	72.8
Saipan Int'l	GSN	99	548,170	—	—
Midland Int'l	MAF	100	532,202	767,000	44.1

Totals: 1992 Enplanements 473,664,350
2005 Enplanements 775,270,000
Overall Growth at the Top 100 Airports 63.7

2. At the top 100 airports, ranked by 1992 enplanements, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts.*

Table A-3. Total Airport Operations, 1992 and Forecast 2005[4]

City-Airport	Airport ID	Rank	Operations FY92	Operations FY2005	% Growth
Chicago O'Hare Int'l	ORD	1	838,093	848,000	1.2
Dallas-Fort Worth Int'l	DFW	2	763,372	1,097,000	43.7
Los Angeles Int'l	LAX	3	678,398	826,000	21.8
William B. Hartsfield Atlanta Int'l	ATL	4	611,889	818,000	33.7
Santa Ana John Wayne	SNA	5	557,442	706,000	26.6
Denver Stapleton Int'l	DEN	6	499,001	664,000	33.1
Phoenix Sky Harbor Int'l	PHX	7	487,615	617,000	26.5
Miami Int'l	MIA	8	486,222	635,000	30.6
Boston Logan Int'l	BOS	9	482,582	544,000	12.7
Charlotte/Douglas Int'l	CLT	10	466,351	582,000	24.8
Lambert St. Louis Int'l	STL	11	429,473	555,000	29.2
San Francisco Int'l	SFO	12	424,829	657,000	54.7
Greater Pittsburgh Int'l	PIT	13	421,903	542,000	28.5
Metropolitan Oakland Int'l	OAK	14	419,233	600,000	43.1
Honolulu Int'l	HNL	15	413,725	517,000	25.0
Detroit Metropolitan Wayne County	DTW	16	413,544	557,000	34.7
Las Vegas McCarran Int'l	LAS	17	407,668	500,000	22.6
Minneapolis-St. Paul Int'l	MSP	18	404,243	582,000	44.0
Newark Int'l	EWR	19	403,978	468,000	15.8
Philadelphia Int'l	PHL	20	377,033	516,000	36.9
Seattle-Tacoma Int'l	SEA	21	346,180	435,000	25.7
Memphis Int'l	MEM	22	344,655	519,000	50.6
San Jose Int'l	SJC	23	342,918	532,000	55.1
New York LaGuardia	LGA	24	337,279	370,000	9.7
New York John F. Kennedy Int'l	JFK	25	328,528	411,000	25.1
Houston Intercontinental	IAH	26	320,234	457,000	42.7
Salt Lake City Int'l	SLC	27	316,783	412,000	30.1
Washington National	DCA	28	312,014	365,000	17.0
Greater Cincinnati Int'l	CVG	29	304,214	538,000	76.8
Nashville Int'l	BNA	30	302,030	403,000	33.4
Orlando Int'l	MCO	31	294,387	561,000	90.6
Raleigh-Durham Int'l	RDU	32	289,462	458,000	58.2
Washington Dulles Int'l	IAD	33	287,111	390,000	35.8
Portland Int'l	PDX	34	269,445	296,000	9.9
Baltimore-Washington Int'l	BWI	35	265,844	350,000	31.7
Indianapolis Int'l	IND	36	247,553	368,000	48.7
Houston William P. Hobby	HOU	37	242,999	336,000	38.3
Cleveland Hopkins Int'l	CLE	38	237,216	285,000	20.1
Anchorage Int'l	ANC	39	236,719	285,000	20.4
Tucson Int'l	TUS	40	235,309	453,000	92.5
Tampa Int'l	TPA	41	229,470	340,000	48.2
Colorado Springs Municipal	COS	42	228,714	286,000	25.0
Palm Beach Int'l	PBI	43	225,784	240,000	6.3

4. At the top 100 airports, ranked by 1992 operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-3. Total Airport Operations, 1992 and Forecast 2005[4]

City-Airport	Airport ID	Rank	Operations FY92	Operations FY2005	% Growth
Port Columbus Int'l	CMH	44	224,598	291,000	29.6
San Diego Int'l Lindberg Field	SAN	45	214,844	333,000	55.0
Burbank-Glendale-Pasadena	BUR	46	214,361	270,000	26.0
Dallas-Love Field	DAL	47	212,049	387,000	82.5
Albuquerque Int'l	ABQ	48	211,601	264,000	24.8
San Antonio Int'l	SAT	49	210,063	300,000	42.8
San Juan Luis Muñoz Marín Int'l	SJU	50	205,560	286,000	39.1
Ft. Lauderdale-Hollywood Int'l	FLL	51	204,183	290,000	42.0
Milwaukee General Mitchell Int'l	MKE	52	202,286	256,000	26.6
Islip Long Island Mac Arthur	ISP	53	202,008	290,000	43.6
Tulsa Int'l	TUL	54	196,835	258,000	31.1
Greater Rochester Int'l	ROC	55	194,764	297,000	52.5
Austin Robert Mueller Municipal	AUS	56	186,796	351,000	87.9
Chicago Midway	MDW	57	184,000	239,000	29.9
Kahului	OGG	58	179,808	255,000	41.8
Wichita Mid-Continent	ICT	59	178,853	309,000	72.8
Kansas City Int'l	MCI	60	176,754	278,000	57.3
Syracuse Hancock Int'l	SYR	61	176,567	255,000	44.4
Birmingham	BHM	62	175,986	253,000	43.8
Bradley Int'l	BDL	63	175,109	318,000	81.6
Oklahoma City Will Rogers World	OKC	64	163,336	172,000	5.3
Sacramento Metropolitan	SMF	65	162,995	294,000	80.4
Little Rock Adams Field	LIT	66	162,439	275,000	69.3
Albany County	ALB	67	162,225	234,000	44.2
Reno Cannon Int'l	RNO	68	161,839	235,000	45.2
Sarasota Bradenton	SRQ	69	161,749	200,000	23.6
Boise Air Terminal	BOI	70	161,434	282,000	74.7
El Paso Int'l	ELP	71	159,710	273,000	70.9
Louisville Standiford Field	SDF	72	156,083	210,000	34.5
Omaha Eppley Airfield	OMA	73	155,058	189,000	21.9
Ontario Int'l	ONT	74	152,935	347,000	126.9
Grand Rapids Kent County Int'l	GRR	75	152,260	227,000	49.1
Dayton Int'l	DAY	76	149,879	231,000	54.1
Providence Green State	PVD	77	146,937	170,000	15.7
Jacksonville Int'l	JAX	78	146,436	183,000	25.0
Richmond Int'l	RIC	79	145,079	209,000	44.1
Dane County Regional	MSN	80	140,890	216,000	53.3
Des Moines Int'l	DSM	81	139,135	165,000	18.6
Norfolk Int'l	ORF	82	138,084	217,000	57.2
New Orleans Int'l	MSY	83	137,373	204,000	48.5
Greater Buffalo Int'l	BUF	84	136,043	186,000	36.7
Charleston AFB Int'l	CHS	85	135,599	183,000	35.0
Knoxville McGhee-Tyson	TYS	86	130,640	160,000	22.5

4. At the top 100 airports, ranked by 1992 operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-3. Total Airport Operations, 1992 and Forecast 2005[4]

City-Airport	Airport ID	Rank	Operations FY92	FY2005	% Growth
Greensboro Piedmont Triad Int'l	GSO	87	130,026	196,000	50.7
Spokane Int'l	GEG	88	124,506	199,000	59.8
Lihue	LIH	89	123,105	163,000	32.4
Portland Int'l Jetport	PWM	90	117,121	159,000	35.8
Lubbock Int'l	LBB	91	113,035	163,000	44.2
Charlotte Amalie St. Thomas (VI)	STT	92	108,796	135,000	24.1
Harrisburg Int'l	MDT	93	95,916	160,000	66.8
Midland Int'l	MAF	94	92,464	166,000	79.5
Hilo Int'l	ITO	95	89,284	112,000	25.4
Fort Myers SW Florida Regional	RSW	96	62,578	141,000	125.3
Kailua-Kona Keahole	KOA	97	61,172	96,000	56.9
Greer Greenville-Spartanburg	GSP	98	60,561	103,000	70.1
Saipan Int'l	GSN	99	—	—	—
Guam Agana Field	NGM	100	—	—	—

Totals: 1992 Operations 25,095,189

2005 Operations 34,556,000

Overall Growth at the Top 100 Airports 37.7

4. At the top 100 airports, ranked by 1992 operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-4. Growth in Enplanements From 1991 to 1992[5]

City-Airport	Airport ID	Rank	Enplanements FY91	Enplanements FY92	% Growth
Port Columbus Int'l	CMH	1	1,698,021	2,358,521	38.9
Nashville Int'l	BNA	2	4,300,568	5,068,011	17.8
Sacramento Metropolitan	SMF	3	2,175,686	2,552,734	17.3
Dane County Regional	MSN	4	469,644	549,723	17.1
Saipan Int'l	GSN	5	468,490	548,170	17.0
Spokane Int'l	GEG	6	797,892	922,609	15.6
Greater Cincinnati Int'l	CVG	7	5,044,813	5,780,241	14.6
Colorado Springs Municipal	COS	8	624,431	712,144	14.0
Reno Cannon Int'l	RNO	9	1,676,197	1,895,183	13.1
Orlando Int'l	MCO	10	8,839,819	9,989,092	13.0
Portland Int'l	PDX	11	3,178,617	3,589,361	12.9
Salt Lake City Int'l	SLC	12	5,800,044	6,510,001	12.2
Greater Pittsburgh Int'l	PIT	13	8,343,024	9,350,221	12.1
William B. Hartsfield Atlanta Int'l	ATL	14	18,886,533	20,966,165	11.0
Harrisburg Int'l	MDT	15	598,095	663,456	10.9
Guam Agana Field	NGM	16	1,112,628	1,233,022	10.8
Boise Air Terminal	BOI	17	585,031	647,554	10.7
Seattle-Tacoma Int'l	SEA	18	7,934,250	8,773,365	10.6
Kahului	OGG	19	2,167,932	2,385,649	10.0
Cleveland Hopkins Int'l	CLE	20	3,885,103	4,266,092	9.8
San Jose Int'l	SJC	21	3,443,484	3,775,332	9.6
Richmond Int'l	RIC	22	872,943	954,165	9.3
Denver Stapleton Int'l	DEN	23	13,270,540	14,476,601	9.1
Knoxville McGhee-Tyson	TYS	24	576,502	628,219	9.0
Lambert St. Louis Int'l	STL	25	9,621,236	10,476,785	8.9
Minneapolis-St. Paul Int'l	MSP	26	9,770,403	10,639,045	8.9
Newark Int'l	EWR	27	11,050,061	11,967,280	8.3
Greensboro Piedmont Triad Int'l	GSO	28	854,572	924,267	8.2
Charlotte/Douglas Int'l	CLT	29	8,425,447	9,099,577	8.0
Dallas-Fort Worth Int'l	DFW	30	24,092,801	25,963,239	7.8
Chicago O'Hare Int'l	ORD	31	27,827,241	29,986,963	7.8
Wichita Mid-Continent	ICT	32	559,966	602,048	7.5
Indianapolis Int'l	IND	33	2,925,853	3,139,728	7.3
Albuquerque Int'l	ABQ	34	2,458,353	2,626,486	6.8
Little Rock Adams Field	LIT	35	977,062	1,043,736	6.8
Raleigh-Durham Int'l	RDU	36	4,640,334	4,939,336	6.4
New York John F. Kennedy Int'l	JFK	37	12,577,222	13,363,580	6.3
Anchorage Int'l	ANC	38	1,592,094	1,691,428	6.2
Houston Intercontinental	IAH	39	8,452,340	8,977,522	6.2
Kansas City Int'l	MCI	40	3,482,600	3,697,821	6.2
Detroit Metropolitan Wayne County	DTW	41	10,354,655	10,986,668	6.1
Houston William P. Hobby	HOU	42	3,781,702	4,008,376	6.0
Ontario Int'l	ONT	43	2,872,927	3,042,508	5.9

5. At the top 100 airports, ranked by growth in total enplanments, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-4. Growth in Enplanements From 1991 to 1992[5]

City-Airport	Airport ID	Rank	Enplanements FY91	FY92	% Growth
Philadelphia Int'l	PHL	44	7,423,013	7,850,375	5.8
Metropolitan Oakland Int'l	OAK	45	3,013,384	3,186,437	5.7
Austin Robert Mueller Municipal	AUS	46	2,051,531	2,169,135	5.7
Milwaukee General Mitchell Int'l	MKE	47	2,043,068	2,157,169	5.6
San Diego Int'l Lindberg Field	SAN	48	5,617,219	5,923,072	5.4
Dallas-Love Field	DAL	49	2,794,424	2,944,942	5.4
Hilo Int'l	ITO	50	667,847	703,736	5.4
San Antonio Int'l	SAT	51	2,597,869	2,730,976	5.1
Santa Ana John Wayne	SNA	52	2,636,331	2,769,936	5.1
Grand Rapids Kent County Int'l	GRR	53	667,456	699,654	4.8
San Juan Luis Muñoz Marín Int'l	SJU	54	4,012,422	4,192,629	4.5
Greer Greenville-Spartanburg	GSP	55	529,573	553,026	4.4
Jacksonville Int'l	JAX	56	1,277,495	1,333,935	4.4
Oklahoma City Will Rogers World	OKC	57	1,482,882	1,543,566	4.1
Las Vegas McCarran Int'l	LAS	58	9,653,154	10,038,181	4.0
Burbank-Glendale-Pasadena	BUR	59	1,843,247	1,913,912	3.8
Ft. Lauderdale-Hollywood Int'l	FLL	60	3,960,913	4,109,796	3.8
Albany County	ALB	61	976,174	1,011,344	3.6
Louisville Standiford Field	SDF	62	1,001,745	1,036,889	3.5
Portland Int'l Jetport	PWM	63	550,953	569,775	3.4
Lubbock Int'l	LBB	64	564,603	583,156	3.3
Tucson Int'l	TUS	65	1,218,426	1,254,597	3.0
Bradley Int'l	BDL	66	2,232,166	2,297,791	2.9
Boston Logan Int'l	BOS	67	10,338,977	10,641,027	2.9
Tulsa Int'l	TUL	68	1,420,331	1,459,526	2.8
New Orleans Int'l	MSY	69	3,255,817	3,340,961	2.6
Kailua-Kona Keahole	KOA	70	996,564	1,022,344	2.6
El Paso Int'l	ELP	71	1,671,354	1,702,205	1.8
Los Angeles Int'l	LAX	72	22,519,698	22,911,585	1.7
Washington National	DCA	73	7,219,161	7,331,346	1.6
Birmingham	BHM	74	967,754	981,171	1.4
Providence Green State	PVD	75	1,108,383	1,120,491	1.1
Honolulu Int'l	HNL	76	10,113,891	10,220,760	1.1
Tampa Int'l	TPA	77	4,748,930	4,793,304	0.9
Charleston AFB Int'l	CHS	78	640,775	645,762	0.8
Miami Int'l	MIA	79	12,492,320	12,587,255	0.8
Memphis Int'l	MEM	80	3,932,939	3,958,432	0.6
San Francisco Int'l	SFO	81	15,186,626	15,257,138	0.5
Greater Rochester Int'l	ROC	82	1,160,582	1,159,306	-0.1
Greater Buffalo Int'l	BUF	83	1,631,868	1,628,534	-0.2
New York LaGuardia	LGA	84	9,788,285	9,751,311	-0.4
Palm Beach Int'l	PBI	85	2,524,206	2,514,095	-0.4
Des Moines Int'l	DSM	86	718,927	715,587	-0.5

5. At the top 100 airports, ranked by growth in total enplanments, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-4. Growth in Enplanements From 1991 to 1992[5]

City-Airport	Airport ID	Rank	Enplanements FY91	Enplanements FY92	% Growth
Fort Myers SW Florida Regional	RSW	87	1,708,824	1,692,442	-1.0
Islip Long Island Mac Arthur	ISP	88	556,599	550,762	-1.0
Norfolk Int'l	ORF	89	1,266,060	1,251,548	-1.1
Midland Int'l	MAF	90	538,689	532,202	-1.2
Phoenix Sky Harbor Int'l	PHX	91	11,111,486	10,958,400	-1.4
Omaha Eppley Airfield	OMA	92	1,104,414	1,085,448	-1.7
Washington Dulles Int'l	IAD	93	5,407,070	5,308,389	-1.8
Charlotte Amalie St. Thomas (VI)	STT	94	602,373	583,817	-3.1
Sarasota Bradenton	SRQ	95	923,212	882,365	-4.4
Syracuse Hancock Int'l	SYR	96	1,186,994	1,120,011	-5.6
Lihue	LIH	97	1,259,368	1,111,730	-11.7
Baltimore-Washington Int'l	BWI	98	4,966,257	4,370,829	-12.0
Chicago Midway	MDW	99	3,241,851	2,029,124	-37.4
Dayton Int'l	DAY	100	1,975,478	1,099,090	-44.4

Totals: 1991 Enplanements 450,169,114
1992 Enplanements 473,664,350
Overall Growth at the Top 100 Airports 5.2

5. At the top 100 airports, ranked by growth in total enplanments, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-5. Growth in Operations From 1991 to 1992[6]

City-Airport	Airport ID	Rank	Operations FY91	FY92	% Growth
Colorado Springs Municipal	COS	1	189,195	228,714	20.9
Little Rock Adams Field	LIT	2	140,255	162,439	15.8
Lihue	LIH	3	109,903	123,105	12.0
Spokane Int'l	GEG	4	111,912	124,506	11.3
Nashville Int'l	BNA	5	274,139	302,030	10.2
Oklahoma City Will Rogers World	OKC	6	148,712	163,336	9.8
Boston Logan Int'l	BOS	7	440,715	482,582	9.5
Greater Pittsburgh Int'l	PIT	8	386,260	421,903	9.2
New York John F. Kennedy Int'l	JFK	9	304,315	328,528	8.0
Washington Dulles Int'l	IAD	10	267,007	287,111	7.5
Sacramento Metropolitan	SMF	11	152,161	162,995	7.1
Memphis Int'l	MEM	12	321,814	344,655	7.1
Raleigh-Durham Int'l	RDU	13	270,534	289,462	7.0
Orlando Int'l	MCO	14	275,157	294,387	7.0
Greater Rochester Int'l	ROC	15	182,613	194,764	6.7
Kailua-Kona Keahole	KOA	16	57,553	61,172	6.3
Greater Buffalo Int'l	BUF	17	128,205	136,043	6.1
Detroit Metropolitan Wayne County	DTW	18	390,863	413,544	5.8
Newark Int'l	EWR	19	381,850	403,978	5.8
Indianapolis Int'l	IND	20	234,045	247,553	5.8
Charlotte/Douglas Int'l	CLT	21	440,956	466,351	5.8
Boise Air Terminal	BOI	22	152,746	161,434	5.7
Minneapolis-St. Paul Int'l	MSP	23	382,856	404,243	5.6
Kansas City Int'l	MCI	24	168,193	176,754	5.1
Port Columbus Int'l	CMH	25	213,723	224,598	5.1
Honolulu Int'l	HNL	26	393,709	413,725	5.1
Salt Lake City Int'l	SLC	27	301,755	316,783	5.0
Washington National	DCA	28	297,559	312,014	4.9
Tulsa Int'l	TUL	29	187,830	196,835	4.8
Portland Int'l Jetport	PWM	30	111,834	117,121	4.7
Dallas-Fort Worth Int'l	DFW	31	731,070	763,372	4.4
Lambert St. Louis Int'l	STL	32	412,539	429,473	4.1
San Diego Int'l Lindberg Field	SAN	33	206,424	214,844	4.1
Albany County	ALB	34	156,448	162,225	3.7
Anchorage Int'l	ANC	35	228,432	236,719	3.6
Chicago O'Hare Int'l	ORD	36	808,759	838,093	3.6
Dane County Regional	MSN	37	136,093	140,890	3.5
Houston Intercontinental	IAH	38	310,404	320,234	3.2
Charleston AFB Int'l	CHS	39	131,444	135,599	3.2
Wichita Mid-Continent	ICT	40	173,722	178,853	3.0
Los Angeles Int'l	LAX	41	660,680	678,398	2.7
Richmond Int'l	RIC	42	141,300	145,079	2.7
San Juan Luis Muñoz Marín Int'l	SJU	43	200,292	205,560	2.6

6. At the top 100 airports, ranked by growth in total operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-5. Growth in Operations From 1991 to 1992[6]

City-Airport	Airport ID	Rank	Operations FY91	Operations FY92	% Growth
Bradley Int'l	BDL	44	171,063	175,109	2.4
Las Vegas McCarran Int'l	LAS	45	398,637	407,668	2.3
Austin Robert Mueller Municipal	AUS	46	182,831	186,796	2.2
Greater Cincinnati Int'l	CVG	47	297,963	304,214	2.1
Dallas-Love Field	DAL	48	208,015	212,049	1.9
San Jose Int'l	SJC	49	336,928	342,918	1.8
Portland Int'l	PDX	50	264,854	269,445	1.7
Seattle-Tacoma Int'l	SEA	51	340,411	346,180	1.7
Denver Stapleton Int'l	DEN	52	491,275	499,001	1.6
New York LaGuardia	LGA	53	332,930	337,279	1.3
Metropolitan Oakland Int'l	OAK	54	413,916	419,233	1.3
Santa Ana John Wayne	SNA	55	550,602	557,442	1.2
Charlotte Amalie St. Thomas (VI)	STT	56	107,563	108,796	1.1
Reno Cannon Int'l	RNO	57	160,107	161,839	1.1
Miami Int'l	MIA	58	481,709	486,222	0.9
Palm Beach Int'l	PBI	59	223,775	225,784	0.9
Greer Greenville-Spartanburg	GSP	60	60,388	60,561	0.3
Tucson Int'l	TUS	61	234,872	235,309	0.2
Midland Int'l	MAF	62	92,393	92,464	0.1
Hilo Int'l	ITO	63	89,252	89,284	0.0
Albuquerque Int'l	ABQ	64	211,561	211,601	0.0
Kahului	OGG	65	181,780	179,808	-1.1
Louisville Standiford Field	SDF	66	158,050	156,083	-1.2
Philadelphia Int'l	PHL	67	382,646	377,033	-1.5
Milwaukee General Mitchell Int'l	MKE	68	205,587	202,286	-1.6
Tampa Int'l	TPA	69	233,650	229,470	-1.8
San Antonio Int'l	SAT	70	213,910	210,063	-1.8
Ontario Int'l	ONT	71	156,306	152,935	-2.2
Phoenix Sky Harbor Int'l	PHX	72	499,157	487,615	-2.3
San Francisco Int'l	SFO	73	435,309	424,829	-2.4
Ft. Lauderdale-Hollywood Int'l	FLL	74	209,752	204,183	-2.7
El Paso Int'l	ELP	75	164,300	159,710	-2.8
Cleveland Hopkins Int'l	CLE	76	244,626	237,216	-3.0
Syracuse Hancock Int'l	SYR	77	182,216	176,567	-3.1
Norfolk Int'l	ORF	78	142,742	138,084	-3.3
Providence Green State	PVD	79	151,994	146,937	-3.3
Des Moines Int'l	DSM	80	144,952	139,135	-4.0
William B. Hartsfield Atlanta Int'l	ATL	81	639,698	611,889	-4.3
Birmingham	BHM	82	184,707	175,986	-4.7
Greensboro Piedmont Triad Int'l	GSO	83	137,275	130,026	-5.3
Omaha Eppley Airfield	OMA	84	164,008	155,058	-5.5
Jacksonville Int'l	JAX	85	155,234	146,436	-5.7
Harrisburg Int'l	MDT	86	101,744	95,916	-5.7

6. At the top 100 airports, ranked by growth in total operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-5. Growth in Operations From 1991 to 1992[6]

City-Airport	Airport ID	Rank	Operations FY91	FY92	% Growth
Baltimore-Washington Int'l	BWI	87	282,320	265,844	-5.8
Fort Myers SW Florida Regional	RSW	88	66,631	62,578	-6.1
Burbank-Glendale-Pasadena	BUR	89	229,492	214,361	-6.6
Sarasota Bradenton	SRQ	90	173,740	161,749	-6.9
Lubbock Int'l	LBB	91	122,130	113,035	-7.4
Houston William P. Hobby	HOU	92	267,199	242,999	-9.1
New Orleans Int'l	MSY	93	152,126	137,373	-9.7
Islip Long Island Mac Arthur	ISP	94	224,691	202,008	-10.1
Grand Rapids Kent County Int'l	GRR	95	171,425	152,260	-11.2
Knoxville McGhee-Tyson	TYS	96	152,638	130,640	-14.4
Dayton Int'l	DAY	97	192,712	149,879	-22.2
Chicago Midway	MDW	98	301,690	184,000	-39.0
Saipan Int'l	GSN	99	—	—	—
Guam Agana Field	NGM	100	—	—	—

Totals: 1991 Operations 24,793,458
1992 Operations 25,095,189
Overall Growth at the Top 100 Airports 1.2

6. At the top 100 airports, ranked by growth in total operations, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY91-FY92	% Growth in Enplanements FY92-FY05	% Growth in Operations FY91-FY92	% Growth in Operations FY92-FY05
Albuquerque Int'l	ABQ	6.8	62.2	0.0	24.8
Albany County	ALB	3.6	62.2	3.7	44.2
Anchorage Int'l	ANC	6.2	50.1	3.6	20.4
William B. Hartsfield Atlanta Int'l	ATL	11.0	34.9	-4.3	33.7
Austin Robert Mueller Municipal	AUS	5.7	118.5	2.2	87.9
Bradley Int'l	BDL	2.9	66.2	2.4	81.6
Birmingham	BHM	1.4	62.6	-4.7	43.8
Nashville Int'l	BNA	17.8	62.1	10.2	33.4
Boise Air Terminal	BOI	10.7	56.4	5.7	74.7
Boston Logan Int'l	BOS	2.9	61.0	9.5	12.7
Greater Buffalo Int'l	BUF	-0.2	65.5	6.1	36.7
Burbank-Glendale-Pasadena	BUR	3.8	33.4	-6.6	26.0
Baltimore-Washington Int'l	BWI	-12.0	66.1	-5.8	31.7
Charleston AFB Int'l	CHS	0.8	73.3	3.2	35.0
Cleveland Hopkins Int'l	CLE	9.8	40.3	-3.0	20.1
Charlotte/Douglas Int'l	CLT	8.0	56.5	5.8	24.8
Port Columbus Int'l	CMH	38.9	41.0	5.1	29.6
Colorado Springs Municipal	COS	14.0	76.4	20.9	25.0
Greater Cincinnati Int'l	CVG	14.6	112.0	2.1	76.8
Dallas-Love Field	DAL	5.4	50.6	1.9	82.5
Dayton Int'l	DAY	-44.4	119.7	-22.2	54.1
Washington National	DCA	1.6	19.7	4.9	17.0
Denver Stapleton Int'l	DEN	9.1	91.2	1.6	33.1
Dallas-Fort Worth Int'l	DFW	7.8	72.1	4.4	43.7
Des Moines Int'l	DSM	-0.5	70.5	-4.0	18.6
Detroit Metropolitan Wayne County	DTW	6.1	72.5	5.8	34.7
El Paso Int'l	ELP	1.8	54.7	-2.8	70.9
Newark Int'l	EWR	8.3	73.7	5.8	15.8
Ft. Lauderdale-Hollywood Int'l	FLL	3.8	97.8	-2.7	42.0
Spokane Int'l	GEG	15.6	76.2	11.3	59.8
Grand Rapids Kent County Int'l	GRR	4.8	55.6	-11.2	49.1
Saipan Int'l	GSN	17.0	—	—	—
Greensboro Piedmont Triad Int'l	GSO	8.2	58.2	-5.3	50.7
Greer Greenville-Spartanburg	GSP	4.4	46.3	0.3	70.1
Honolulu Int'l	HNL	1.1	36.8	5.1	25.0
Houston William P. Hobby	HOU	6.0	29.8	-9.1	38.3
Washington Dulles Int'l	IAD	-1.8	104.8	7.5	35.8
Houston Intercontinental	IAH	6.2	48.7	3.2	42.7
Wichita Mid-Continent	ICT	7.5	82.0	3.0	72.8
Indianapolis Int'l	IND	7.3	40.2	5.8	48.7
Islip Long Island Mac Arthur	ISP	-1.0	50.3	-10.1	43.6
Hilo Int'l	ITO	5.4	43.4	0.0	25.4
Jacksonville Int'l	JAX	4.4	78.9	-5.7	25.0

7. At the top 100 airports, listed in alphabetical order by Airport Identifier, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY91-FY92	% Growth in Enplanements FY92-FY05	% Growth in Operations FY91-FY92	% Growth in Operations FY92-FY05
New York John F. Kennedy Int'l	JFK	6.3	38.5	8.0	25.1
Kailua-Kona Keahole	KOA	2.6	73.2	6.3	56.9
Las Vegas McCarran Int'l	LAS	4.0	82.8	2.3	22.6
Los Angeles Int'l	LAX	1.7	40.8	2.7	21.8
Lubbock Int'l	LBB	3.3	44.0	-7.4	44.2
New York LaGuardia	LGA	-0.4	45.5	1.3	9.7
Lihue	LIH	-11.7	61.6	12.0	32.4
Little Rock Adams Field	LIT	6.8	53.7	15.8	69.3
Midland Int'l	MAF	-1.2	44.1	0.1	79.5
Kansas City Int'l	MCI	6.2	84.6	5.1	57.3
Orlando Int'l	MCO	13.0	65.6	7.0	90.6
Harrisburg Int'l	MDT	10.9	110.7	-5.7	66.8
Chicago Midway	MDW	-37.4	62.0	-39.0	29.9
Memphis Int'l	MEM	0.6	84.7	7.1	50.6
Miami Int'l	MIA	0.8	58.9	0.9	30.6
Milwaukee General Mitchell Int'l	MKE	5.6	102.4	-1.6	26.6
Dane County Regional	MSN	17.1	72.8	3.5	53.3
Minneapolis-St. Paul Int'l	MSP	8.9	54.8	5.6	44.0
New Orleans Int'l	MSY	2.6	78.1	-9.7	48.5
Guam Agana Field	NGM	10.8	—	—	—
Metropolitan Oakland Int'l	OAK	5.7	37.4	1.3	43.1
Kahului	OGG	10.0	42.5	-1.1	41.8
Oklahoma City Will Rogers World	OKC	4.1	83.5	9.8	5.3
Omaha Eppley Airfield	OMA	-1.7	58.9	-5.5	21.9
Ontario Int'l	ONT	5.9	198.1	-2.2	126.9
Chicago O'Hare Int'l	ORD	7.8	56.7	3.6	1.2
Norfolk Int'l	ORF	-1.1	72.7	-3.3	57.2
Palm Beach Int'l	PBI	-0.4	78.9	0.9	6.3
Portland Int'l	PDX	12.9	51.3	1.7	9.9
Philadelphia Int'l	PHL	5.8	70.7	-1.5	36.9
Phoenix Sky Harbor Int'l	PHX	-1.4	75.7	-2.3	26.5
Greater Pittsburgh Int'l	PIT	12.1	66.4	9.2	28.5
Providence Green State	PVD	1.1	33.4	-3.3	15.7
Portland Int'l Jetport	PWM	3.4	83.4	4.7	35.8
Raleigh-Durham Int'l	RDU	6.4	109.0	7.0	58.2
Richmond Int'l	RIC	9.3	76.5	2.7	44.1
Reno Cannon Int'l	RNO	13.1	48.8	1.1	45.2
Greater Rochester Int'l	ROC	-0.1	76.9	6.7	52.5
Fort Myers SW Florida Regional	RSW	-1.0	82.3	-6.1	125.3
San Diego Int'l Lindberg Field	SAN	5.4	76.3	4.1	55.0
San Antonio Int'l	SAT	5.1	42.0	-1.8	42.8
Louisville Standiford Field	SDF	3.5	68.6	-1.2	34.5
Seattle-Tacoma Int'l	SEA	10.6	58.6	1.7	25.7

7. At the top 100 airports, listed in alphabetical order by Airport Identifier, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

Table A-6. Growth in Operations and Enplanements[7]

City-Airport	Airport ID	% Growth in Enplanements FY91-FY92	% Growth in Enplanements FY92-FY05	% Growth in Operations FY91-FY92	% Growth in Operations FY92-FY05
San Francisco Int'l	SFO	0.5	75.4	-2.4	54.7
San Jose Int'l	SJC	9.6	86.6	1.8	55.1
San Juan Luis Muñoz Marín Int'l	SJU	4.5	72.5	2.6	39.1
Salt Lake City Int'l	SLC	12.2	51.8	5.0	30.1
Sacramento Metropolitan	SMF	17.3	97.3	7.1	80.4
Santa Ana John Wayne	SNA	5.1	77.0	1.2	26.6
Sarasota Bradenton	SRQ	-4.4	53.7	-6.9	23.6
Lambert St. Louis Int'l	STL	8.9	74.7	4.1	29.2
Charlotte Amalie St. Thomas (VI)	STT	-3.1	215.2	1.1	24.1
Syracuse Hancock Int'l	SYR	-5.6	75.0	-3.1	44.4
Tampa Int'l	TPA	0.9	89.0	-1.8	48.2
Tulsa Int'l	TUL	2.8	56.1	4.8	31.1
Tucson Int'l	TUS	3.0	95.9	0.2	92.5
Knoxville McGhee-Tyson	TYS	9.0	65.9	-14.4	22.5
Totals: Overall Growth at the Top 100 Airports		5.2	63.7	1.2	37.7

7. At the top 100 airports, listed in alphabetical order by Airport Identifier, based on preliminary data intended for the FAA's annual report, *Terminal Area Forecasts*.

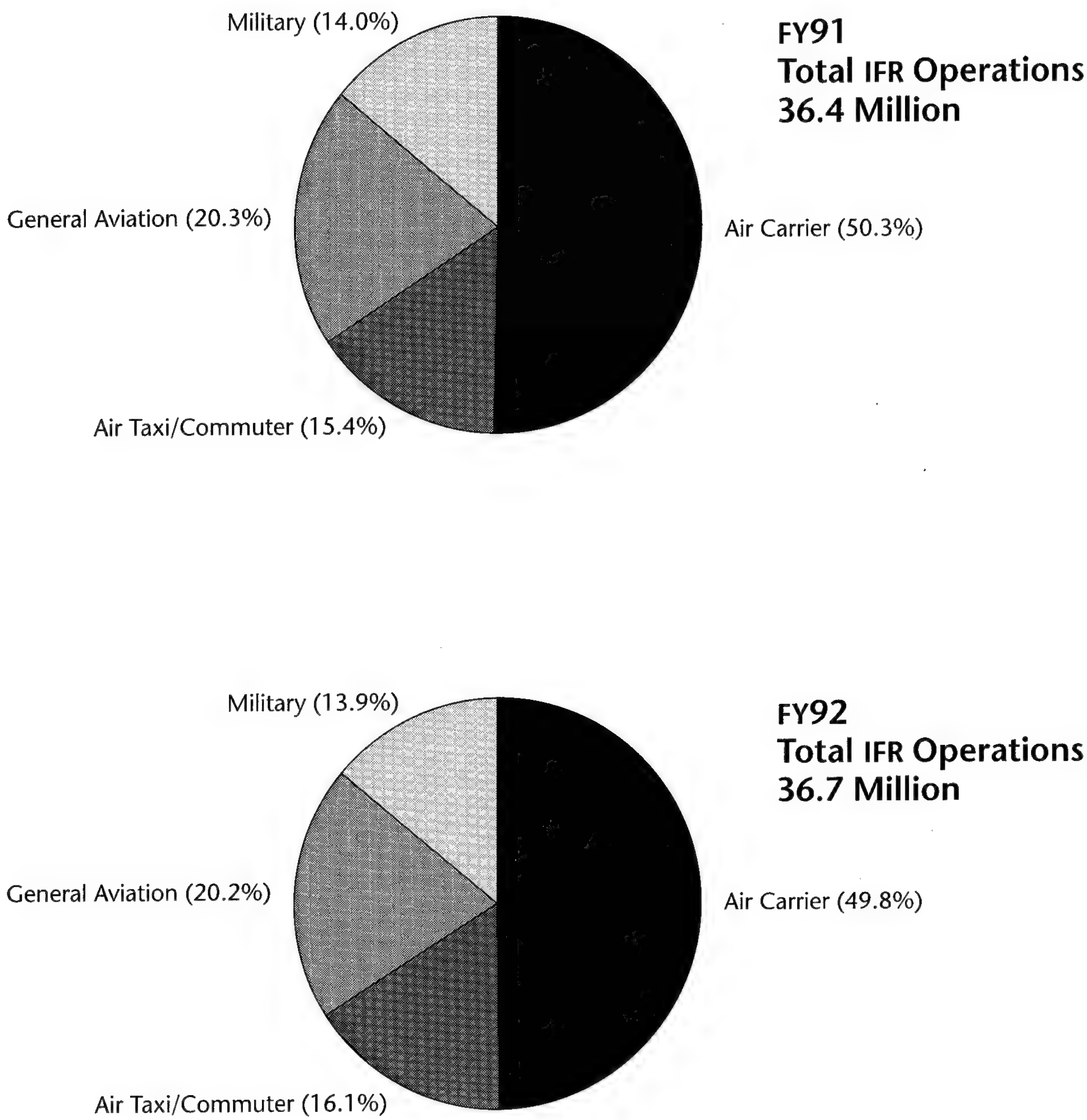
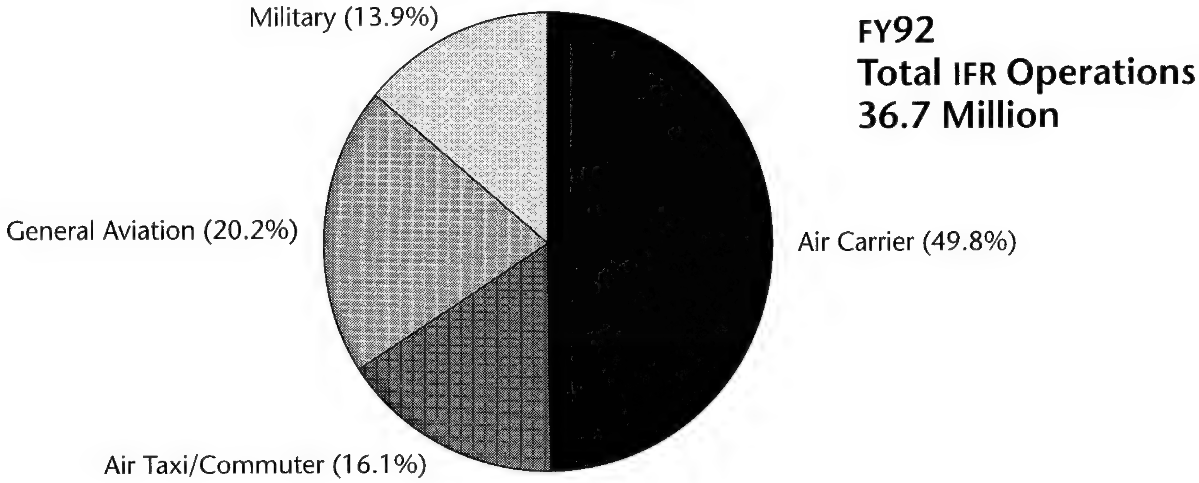


Figure A-1. Traffic Handled by ARTCCs, FY91 and FY92



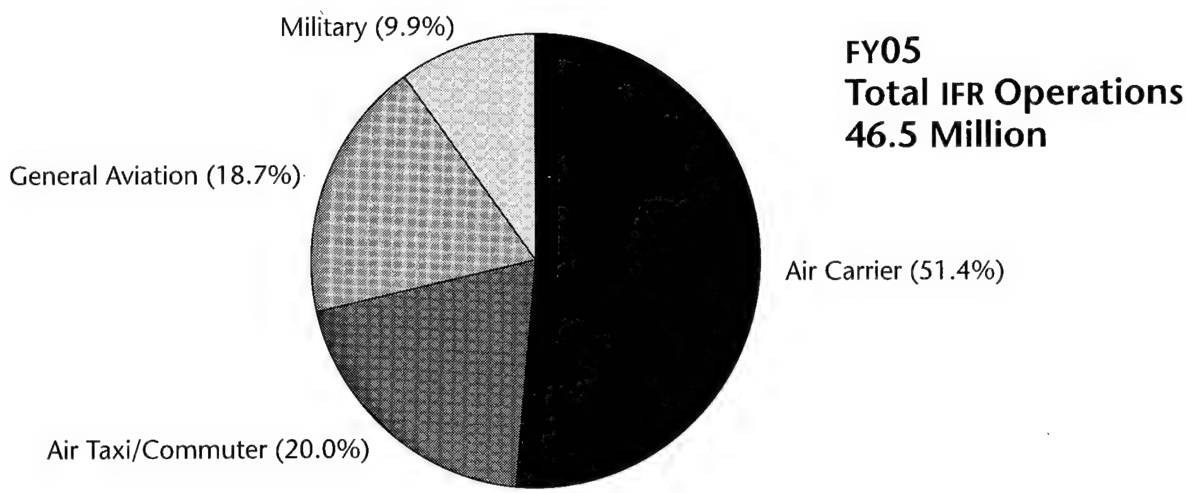


Figure A-2. Traffic Handled by ARTCCs, FY92 and Forecast FY05

Table A-7. Total IFR Aircraft Handled at ARTCCs

Center	FY91	Operations (000) FY92	FY05	% Growth '92-'05
Albuquerque (ZAB)	1,442	1,359	1,707	25.6
Atlanta (ZTL)	2,225	2,221	2,910	31.0
Boston (ZBU)	1,537	1,590	2,064	29.8
Chicago (ZAU)	2,610	2,553	3,517	37.8
Cleveland (ZOB)	2,313	2,396	2,993	24.9
Fort Worth (ZFW)	1,929	1,978	2,510	26.9
Denver (ZDV)	1,442	1,394	1,875	34.5
Houston (ZHU)	1,671	1,660	2,003	20.7
Indianapolis (ZID)	1,870	1,912	2,443	27.8
Jacksonville (ZJX)	1,644	1,643	2,360	43.6
Kansas City (ZKC)	1,679	1,756	2,348	33.7
Los Angeles (ZLA)	1,830	1,776	2,267	27.6
Memphis (ZME)	1,808	1,866	2,468	32.3
Miami (ZMA)	1,767	1,781	2,458	38.0
Minneapolis (ZMP)	1,725	1,774	2,416	36.2
New York (ZNY)	1,935	1,949	2,549	30.8
Oakland (ZOA)	1,685	1,629	2,675	64.2
Salt Lake City (ZLC)	1,250	1,379	1,874	35.9
Seattle (ZSE)	1,279	1,296	1,711	32.0
Washington (ZDC)	2,183	2,212	2,675	20.9

Source: *Forecast of IFR Aircraft Handled by ARTCC FY93-05, May 1993*

Table A-8. Percentage of Operations Delayed 15 Minutes or More

Airports	Percentage of Operations Delayed 15 Minutes or More							
	1985	1986	1987	1988	1989	1990	1991	1992
Newark Int'l.	9.2	13.8	6.5	6.7	10.6	8.5	6.7	8.3
New York La Guardia	9.2	8.9	6.5	5.2	9.6	8.7	6.2	5.5
Chicago O'Hare Int'l.	4.1	5.6	4.6	5.5	10.3	6.5	4.8	4.5
New York Kennedy	6.1	7.0	6.5	5.3	6.1	6.8	4.2	4.1
Boston Logan Int'l.	6.1	7.3	4.8	3.7	2.9	3.2	3.3	3.5
San Francisco Int'l.	3.4	5.3	6.2	6.3	7.1	4.6	5.8	3.0
Dallas-Ft. Worth Int'l.	1.7	2.6	2.0	1.4	2.4	3.2	3.5	3.0
Atlanta Hartsfield Int'l.	6.2	6.5	6.2	3.5	2.5	4.4	2.2	3.0
Denver Stapleton Int'l.	4.6	3.2	3.7	3.7	2.7	2.9	2.9	2.6
Los Angeles Int'l.	0.8	1.1	3.3	1.7	1.1	0.7	1.5	2.0
Philadelphia Int'l.	0.9	2.0	3.7	2.6	2.2	3.5	1.7	1.8
St. Louis-Lambert Int'l.	4.6	4.4	1.6	2.7	2.9	2.5	3.0	1.5
Detroit Metropolitan	2.1	1.3	1.5	1.5	1.6	2.0	0.9	1.1
Washington National	2.0	3.2	2.3	1.5	1.0	1.0	0.5	1.1
Miami Int'l.	0.3	0.7	0.4	0.3	0.2	0.9	2.4	1.0
Houston Intercontinental	0.3	0.2	0.5	0.7	0.6	1.3	1.3	0.8
Pittsburgh Int'l.	1.7	0.6	0.7	0.7	0.8	0.9	0.5	0.8
Minneapolis Int'l.	2.2	3.9	0.7	1.4	0.8	3.2	0.8	0.4
Ft. Lauderdale Int'l.	0.1	0.3	0.2	0.2	0.3	0.3	0.2	0.4
Cleveland Hopkins Int'l.	0.1	0.3	0.1	0.5	0.3	0.5	0.2	0.2
Kansas City Int'l.	0.3	1.0	0.5	0.2	0.3	0.2	0.3	0.1
Las Vegas McCarran Int'l.	0.0	0.0	0.1	0.1	0.2	0.1	0.0	0.0

Appendix B

Airport Layout Directory

State	Airport	ID	Where
Alaska	Anchorage Int'l	ANC	Appendix E
Alabama	Birmingham Municipal	BHM	Appendix E
Arkansas	Little Rock Adams Field	LIT	Appendix D
Arizona	Phoenix Sky Harbor Int'l	PHX	Appendix D
	Tucson Int'l	TUS	Appendix D
California	Burbank-Glendale-Pasadena	BUR	Appendix E
	Los Angeles Int'l	LAX	Appendix E
	Oakland Metro Int'l	OAK	Appendix E
	Ontario Int'l	ONT	Appendix E
	Sacramento Metropolitan	SMF	Appendix E
	San Diego Lindbergh	SAN	Appendix E
	San Francisco Int'l	SFO	Appendix E
	San Jose Int'l	SJC	Appendix E
	Santa Ana John Wayne	SNA	Appendix D

State	Airport	ID	Where
Colorado	Colorado Springs Municipal	COS	Appendix E
	Denver Int'l Airport (replacement)	DEN	Appendix D
	Denver Stapleton Int'l	DEN	Appendix E
Connecticut	Windsor Locks Bradley Int'l	BDL	Appendix E
District of Columbia	Washington Dulles Int'l	IAD	Appendix D
	Washington National	DCA	Appendix E
Florida	Fort Lauderdale Int'l	FLL	Appendix D
	Fort Myers SW Florida Regional	RSW	Appendix D
	Jacksonville Int'l	JAX	Appendix D
	Miami Int'l	MIA	Appendix D
	Orlando Int'l	MCO	Appendix D
	Sarasota-Bradenton	SRQ	Appendix D
	Tampa Int'l	TPA	Appendix D
	West Palm Beach Int'l	PBI	Appendix D
Georgia	Atlanta Hartsfield Int'l	ATL	Appendix D
Hawaii	Hilo General Lyman	ITO	Appendix E
	Honolulu Int'l	HNL	Appendix E
	Kahului	OGG	Appendix D
	Kailua-Kona Keahole	KOA	Appendix E
	Lihue	LIH	Appendix E
Iowa	Des Moines Int'l	DSM	Appendix E
Idaho	Boise Air-Terminal	BOI	Appendix E
Illinois	Chicago Midway	MDW	Appendix E
	Chicago O'Hare Int'l	ORD	Appendix D
Indiana	Indianapolis Int'l	IND	Appendix D
Kansas	Wichita Mid-Continent	ICT	Appendix E
Kentucky	Louisville Standiford Field	SDF	Appendix D
Louisiana	New Orleans Int'l	MSY	Appendix D
Massachusetts	Boston Logan Int'l	BOS	Appendix D
Maryland	Baltimore-Washington Int'l	BWI	Appendix D
Maine	Portland Int'l Jetport	PWM	Appendix E
Michigan	Detroit Metro Wayne County	DTW	Appendix D
	Grand Rapids Kent County Int'l	GRR	Appendix D
Minnesota	Minneapolis-St. Paul Int'l	MSP	Appendix D
Missouri	Kansas City Int'l	MCI	Appendix D
	Lambert St. Louis Int'l	STL	Appendix D
North Carolina	Charlotte/Douglas Int'l	CLT	Appendix D
	Greensboro Piedmont Int'l	GSO	Appendix D
	Raleigh-Durham Int'l	RDU	Appendix D
Nebraska	Omaha Eppley Airfield	OMA	Appendix E
New Jersey	Newark Int'l	EWR	Appendix E
New Mexico	Albuquerque Int'l	ABQ	Appendix D
Nevada	Las Vegas McCarran Int'l	LAS	Appendix D
	Reno Cannon Int'l	RNO	Appendix D

State	Airport	ID	Where
New York	Albany County	ALB	Appendix D
	Buffalo Int'l	BUF	Appendix E
	Islip Long Island	ISP	Appendix D
	John F. Kennedy Int'l	JFK	Appendix E
	LaGuardia	LGA	Appendix E
	Rochester Monroe County	ROC	Appendix D
	Syracuse Hancock Int'l	SYR	Appendix D
Ohio	Cincinnati Int'l	CVG	Appendix D
	Cleveland Hopkins Int'l	CLE	Appendix D
	Dayton Int'l	DAY	Appendix E
	Port Columbus Int'l	CMH	Appendix D
Oklahoma	Oklahoma City Will Rogers	OKC	Appendix D
	Tulsa Int'l	TUL	Appendix D
Oregon	Portland Int'l	PDX	Appendix E
Pennsylvania	Harrisburg Int'l	MDT	Appendix E
	Philadelphia Int'l	PHL	Appendix D
	Pittsburgh Int'l	PIT	Appendix D
Rhode Island	Providence Green State	PVD	Appendix E
South Carolina	Charleston Int'l	CHS	Appendix E
	Greer Greenville-Spartanburg	GSP	Appendix D
Tennessee	Knoxville McGhee-Tyson	TYS	Appendix E
	Memphis Int'l	MEM	Appendix D
	Nashville Int'l	BNA	Appendix D
Texas	Austin Robert Mueller Municipal	AUS	Appendix E
	Bergstrom AFB (new Austin)	BSM	Appendix D
	Dallas-Fort Worth Int'l	DFW	Appendix D
	Dallas Love Field	DAL	Appendix E
	El Paso Int'l	ELP	Appendix D
	Houston Hobby	HOU	Appendix E
	Houston Intercontinental	IAH	Appendix D
	Lubbock Int'l	LBB	Appendix D
	Midland Int'l	MAF	Appendix D
	San Antonio Int'l	SAT	Appendix D
Utah	Salt Lake City Int'l	SLC	Appendix D
Virginia	Norfolk Int'l	ORF	Appendix E
	Richmond Int'l	RIC	Appendix D
Washington	Seattle-Tacoma Int'l	SEA	Appendix D
	Spokane Int'l	GEG	Appendix D
Wisconsin	Milwaukee Mitchell Int'l	MKE	Appendix D
	Dane County Regional	MSN	Appendix D
Guam	Agana Field	NGM	Appendix E
Puerto Rico	San Juan Luis Muñoz Marín Int'l	SJU	Appendix E
Virgin Islands	Charlotte Amalie St. Thomas	STT	Appendix E
Saipan	Saipan International	GSN	Appendix E

Appendix C

Airport Capacity Design Team Project Summaries[1]

Background

Recognizing the problems posed by congestion and delay within the National Airspace System, the Federal Aviation Administration (FAA) asked the aviation community to study the problem of airport congestion through the Industry Task Force on Airport Capacity Improvement and Delay Reduction chaired by the Airport Operators Council International.

By 1984, aircraft delays recorded throughout the system highlighted the need for more centralized management and coordination of activities to relieve airport congestion. In response, the FAA established the Airport Capacity Program Office, now called the Office of System Capacity and Requirements (ASC). The goal of this office and its capacity enhancement program is to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated within the system with a minimum of delay and without compromising safety or the environment.

In 1985, the FAA initiated a renewed program of Airport Capacity Design Teams at various major air carrier airports throughout the U.S. Each Capacity Team identifies and evaluates alternative means to enhance existing airport and airspace capacity to handle future demand and works to develop a coordinated action plan for reducing airport delay. Over 30 Airport Capacity Design Teams have either completed their studies or have work in progress.

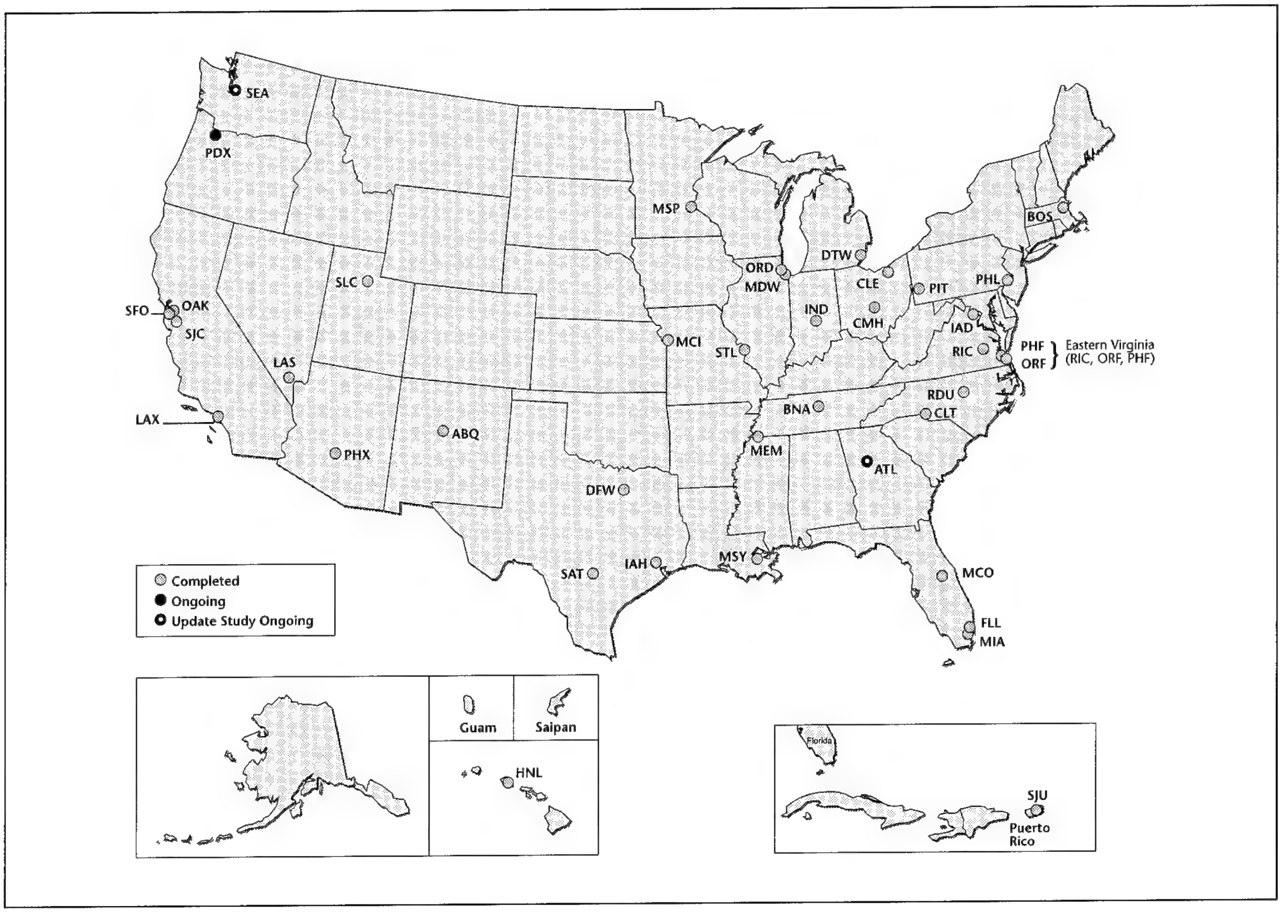
The need for this program continues. In 1993, 23 airports each exceeded 20,000 hours of airline flight delays. If no improvements in capacity are made, the number of airports that could exceed 20,000 hours of annual aircraft delay is projected to grow from 23 to 32 by 2003. The challenge for the air transportation industry in the nineties is to enhance existing airport and airspace capacity and to develop new facilities to handle future demand. As environmental, financial, and other constraints continue to restrict the development of new airport facilities in the U.S., an increased emphasis has been placed on the redevelopment and expansion of existing airport facilities.

Objectives

The major goal of a Capacity Team is to identify and evaluate proposals to increase airport capacity, improve airport efficiency, and reduce aircraft delays while maintaining or improving aviation safety. To achieve this objective, the Capacity Team:

- Assesses the current airport capacity.
- Examines the causes of delay associated with the airfield, the immediate airspace, and the apron and gate-area operations.
- Evaluates capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational improvements, airfield development, and operational improvements.

1. As of 10-01-94.



Scope

The Capacity Team limits its analyses to aircraft activity within the terminal area airspace and on the airfield. They consider the operational benefits of the proposed airfield improvements, but do not address environmental, socioeconomic, or political issues regarding airport development. These issues need to be addressed in future airport planning studies, and the data generated by the Capacity Team can be used in such studies.

Methodology

The Capacity Team, which includes representatives from the FAA, the airport authority of the airport under study, the appropriate State Department of Transportation, various aviation industry groups, and members of the local general aviation community meet periodically for review and coordination. The Capacity Team members consider suggested capacity improvement alternatives proposed by the FAA's Office of System Capacity and Requirements, FAA Technical Center, Regional Aviation Capacity Program Manager, and by other members of the Team. Alternatives which are considered practicable are developed into experiments which can be tested by simulation modeling. The FAA Technical Center's Aviation Capacity Branch provides expertise in airport simulation modeling. The Capacity Team validates the data used as input for the simulation modeling and analysis and reviews the interpretation of the simulation results. The data, assumptions, alternatives, and experiments are continually reevaluated, and modified where necessary, as the study progresses. A primary goal of the study is to develop a set of capacity-producing recommendations, complete with planning and implementation time horizons.

Initial work consists of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions are based on actual field observations at the target airport. Proposed improvements are analyzed in relation to current and future demands with the help of FAA computer models, the Airport and Airspace Simulation Model (SIMMOD), the Runway Delay Simulation Model (RDSIM), and the Airfield Delay Simulator (ADSIM).

The simulation models consider Air Traffic Control procedures, airfield improvements, and traffic demands. Alternative airfield configurations are prepared from present and proposed airport layout plans. Various configurations are evaluated to assess the benefit of projected improvements. Air Traffic Control procedures and system improvements determine the aircraft separations to be used for simulations under both VFR and IFR.

Air traffic demand levels are derived from *Official Airline Guide* data, historical data, and Capacity Team and other forecasts. Aircraft volume, fleet mix, and peaking characteristics are considered for each of the three different demand forecast levels (Baseline, Future 1, and Future 2). From this, annual delay estimates are determined based on implementing various improvements. These estimates take into account historic variations in runway configuration, weather, and demand. Annual delay estimates for each configuration are then compared to identify delay reductions resulting from the improvements. Following the evaluation, the Capacity Team develops a plan of recommended alternatives for consideration.

Reports

Since the renewal of the program in 1985, 37 Airport Capacity Design Team studies have been completed. Currently, three Capacity Design Team studies are in progress. The following listing provides locations and dates for completed studies.

Design Team Completion Dates

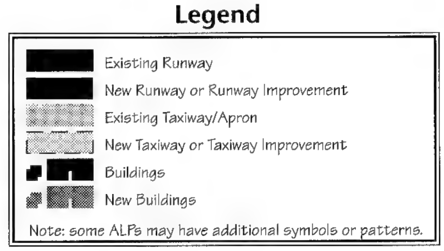
Albuquerque Int'l	1993
Boston Logan Int'l	1992
Charlotte/Douglas Int'l	1991
Chicago Midway	1991
Chicago O'Hare Int'l	1991
Cleveland-Hopkins Int'l	1994
Dallas-Ft. Worth Int'l	1994
Detroit Metropolitan Wayne County	1988
Eastern Virginia Region	1994
Fort Lauderdale-Hollywood Int'l	1993
Greater Pittsburgh Int'l	1991
Honolulu Int'l	1992
Houston Intercontinental	1993
Indianapolis Int'l	1993
Kansas City Int'l	1990
Lambert St. Louis Int'l	1988
Las Vegas McCarran Int'l	1994
Los Angeles Int'l	1991
Memphis Int'l	1988
Metropolitan Orlando Int'l	1990
Miami Int'l	1989
Minneapolis-Saint Paul Int'l	1993
Nashville Int'l	1991
New Orleans Int'l	1992
Oakland Int'l	1987
Philadelphia Int'l	1991
Phoenix Sky Harbor Int'l	1989
Port Columbus Int'l	1993
Raleigh-Durham Int'l	1991
Salt Lake City Int'l	1991
San Antonio Int'l	1992
San Francisco Int'l	1987
San Jose Int'l	1987
San Juan Luis Muñoz Marín Int'l	1991
Seattle-Tacoma Int'l	1991
Washington Dulles Int'l	1990
William B. Hartsfield Atlanta Int'l	1987

Appendix D

New Runway & Runway Extension Construction

Appendix D contains current airport layouts for those airports among the top 100 airports[1] that are considering or have plans for the construction of new runways or extensions to existing runways. The airport layouts show simplified drawings of the existing airports, with proposed runway and runway extension projects indicated in blue. Airport layouts for the remainder of the top 100 airports are contained in Appendix E.

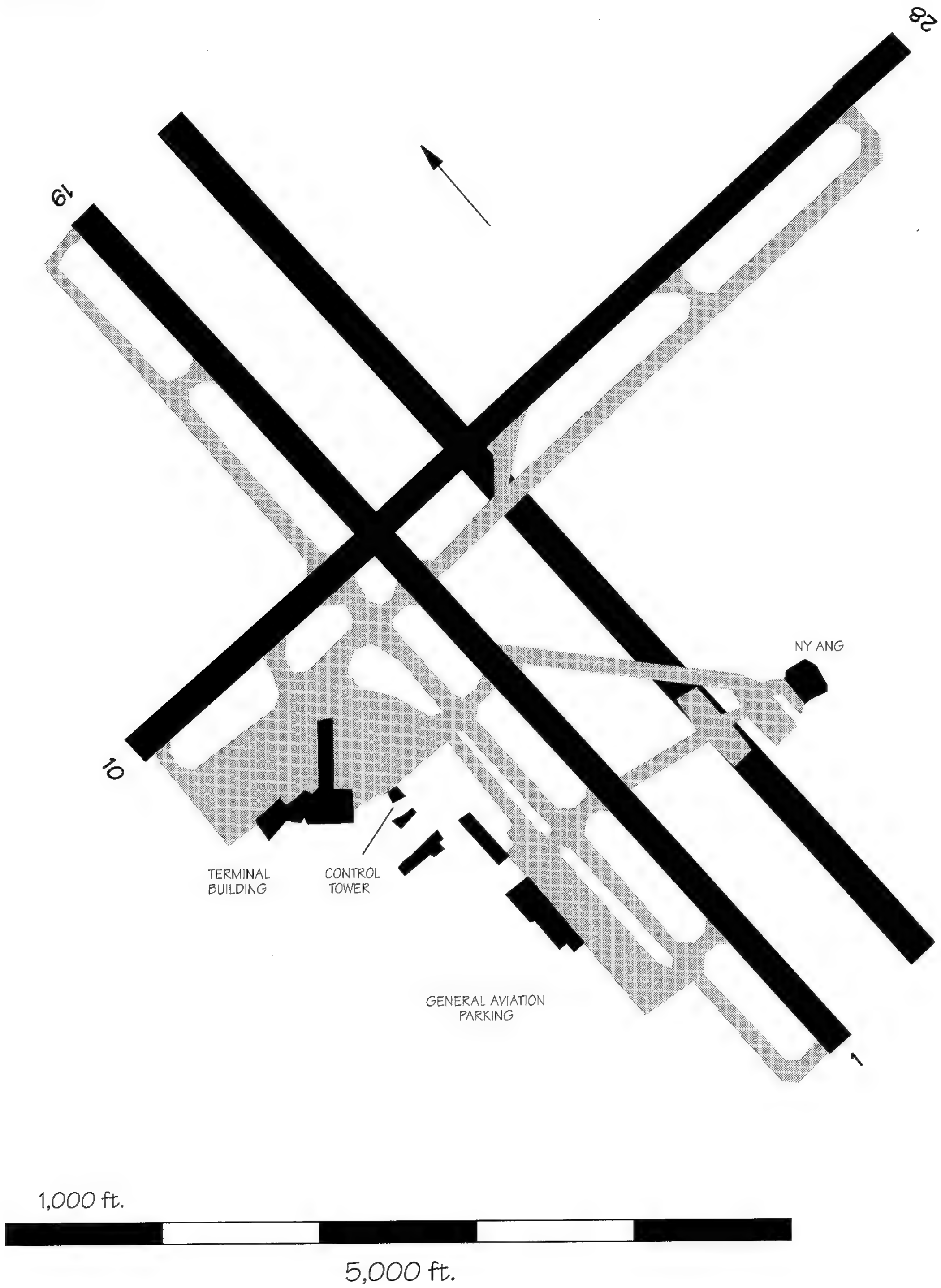
Legend



1. Based on 1992 passenger enplanements (see Appendix A, Table A-1).

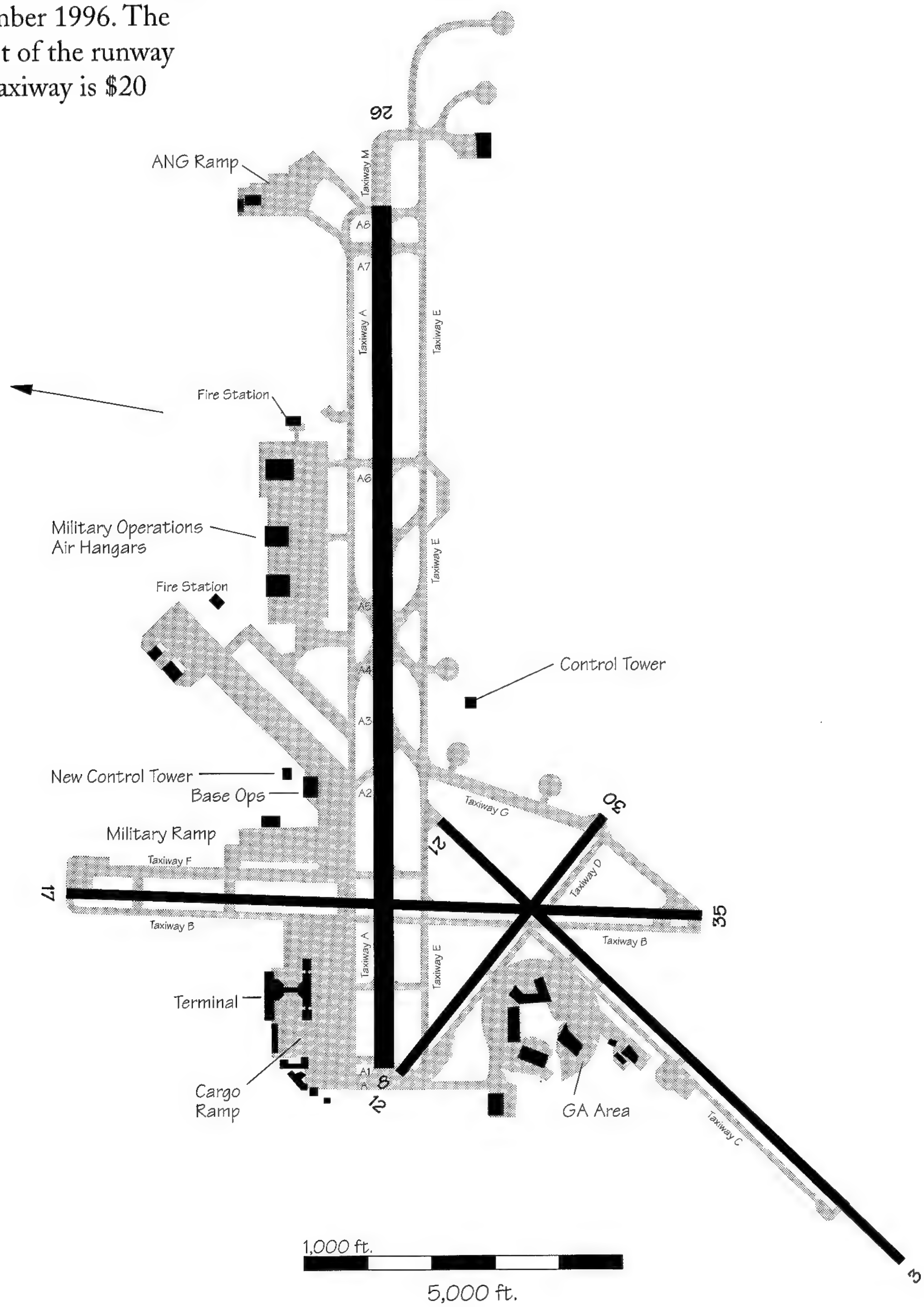
Albany County Airport (ALB)

Construction of an extension to Runway 10/28 is planned. The estimated cost of construction is $5.8 million. A new parallel Runway 1R/19L is also planned. The estimated cost is $7.5 million.



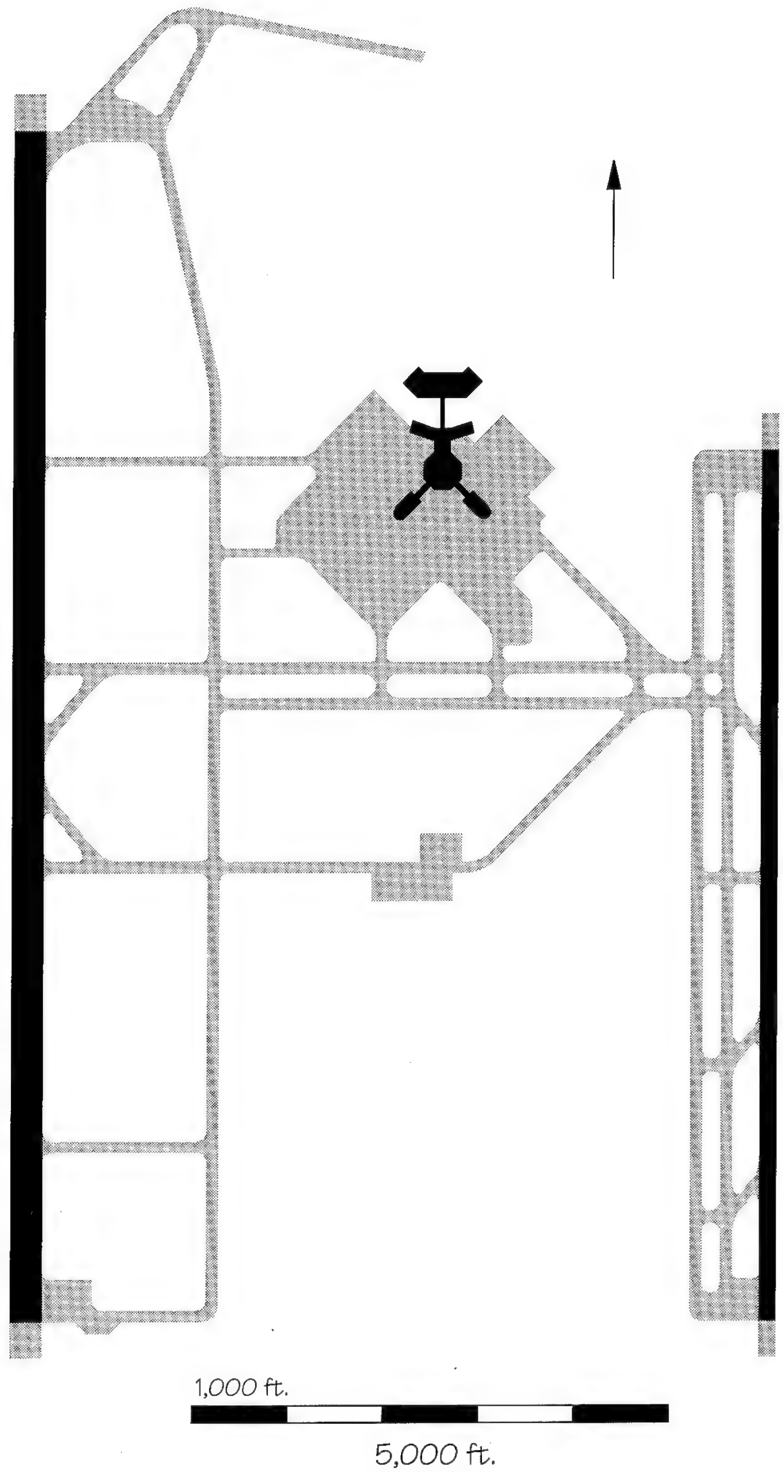
Albuquerque Int'l Airport (ABQ)

A 1,500 foot extension to Runway 3/21 will provide an 8,800 foot runway, eliminating the intersection with Runway 8/26. The expected operational date is December 1996. The estimated cost of the runway and parallel taxiway is $20 million.



Austin Robert Mueller Municipal Airport (Bergstrom) (AUS)

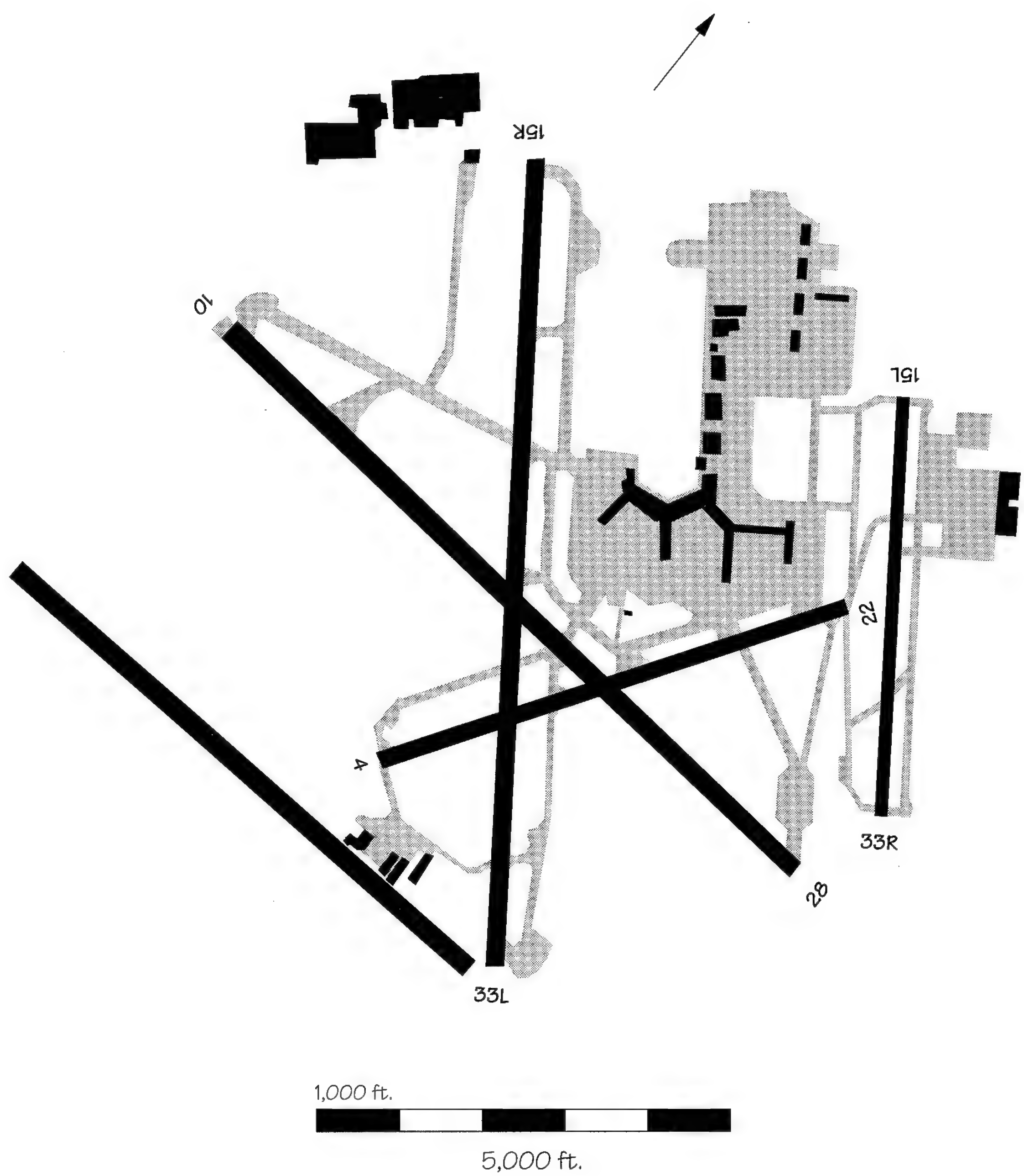
The community has approved the sale of revenue bonds for the development of a new airport. The present Robert Mueller Airport cannot be expanded. Bergstrom Air Force Base (AFB) was transferred to the city on October 1, 1993, and the city is now planning to construct a new parallel runway and relocate all commercial activity there in 1998. The total estimated project cost is $583 million. The city has an Airport Master Plan under development. Environmental studies are in progress by the Air Force and the city. Since Robert Mueller Airport will close upon completion of the new airport, no capacity enhancements are planned at Mueller.



Bergstrom Air Force Base Conversion
Opening Day Layout Plan
as of 1-31-94

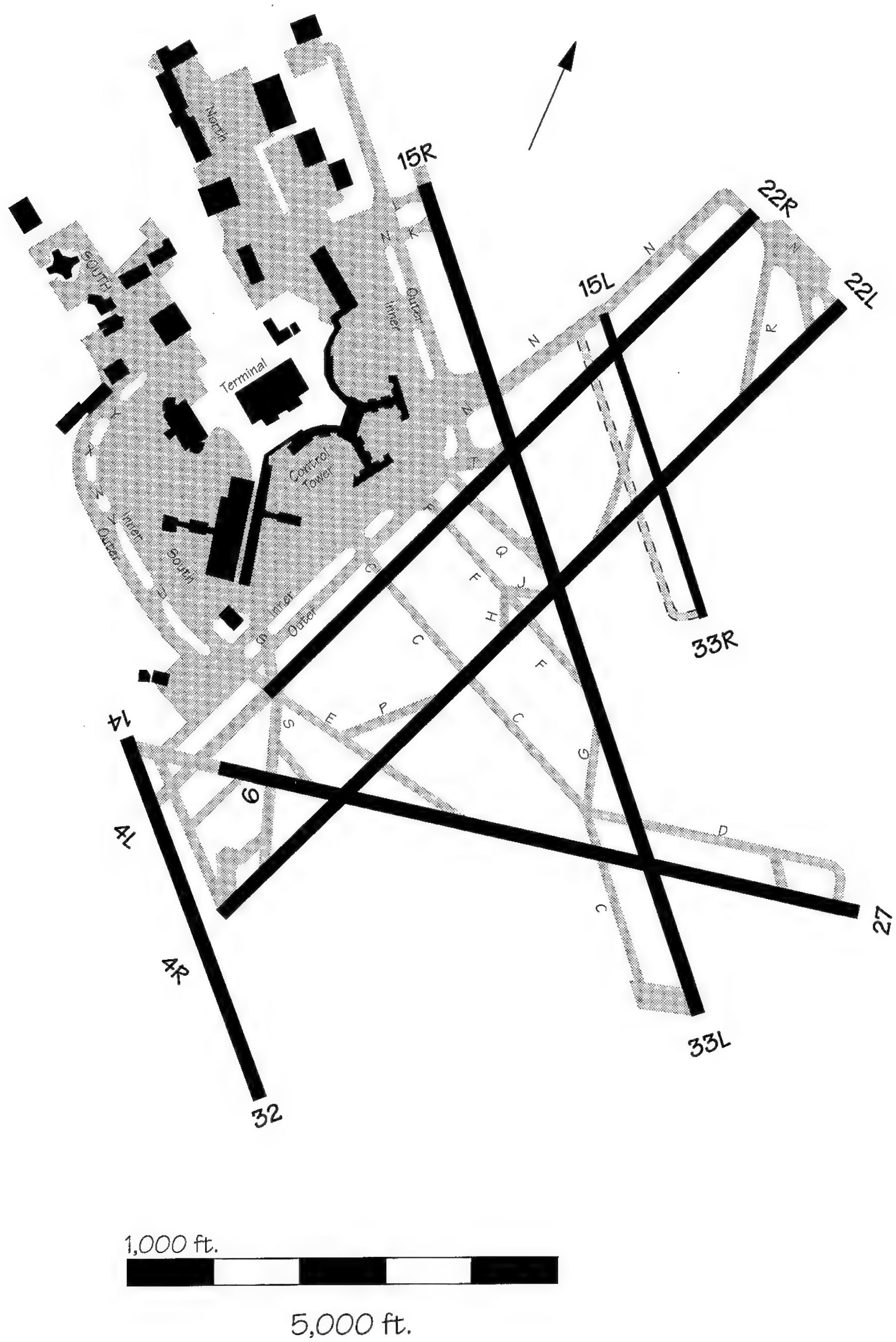
Baltimore-Washington Int'l Airport (BWI)

Construction of an extension of Runway 10/28 began June 1, 1993, and the extension should be operational October 1, 1994. The estimated cost of construction is $12 million. A new 7,800-foot runway, Runway 10R/28L, is planned to be constructed 3,500 feet south of Runway 10/28 by 2003. When Runway 10R/28L is constructed, Runway 4/22 will be converted to a taxiway.



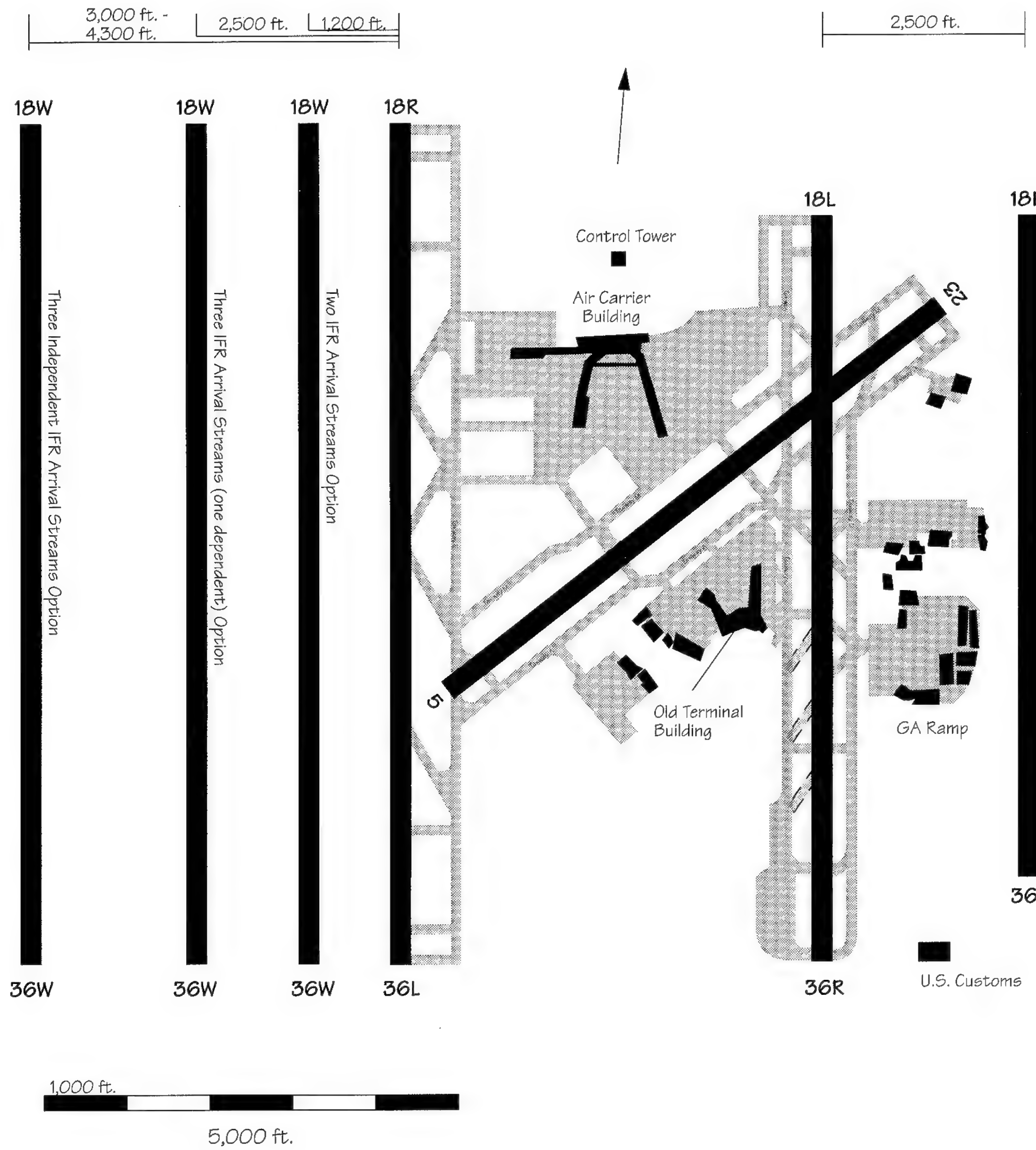
Boston Logan Int'l Airport (BOS)

A new uni-directional commuter runway (Runway 14/32) 4,300 feet from Runway 15R/33L, an extension of Runway 15L/33R to 3,500 feet, and a 400-foot extension of Runway 9 are being studied.



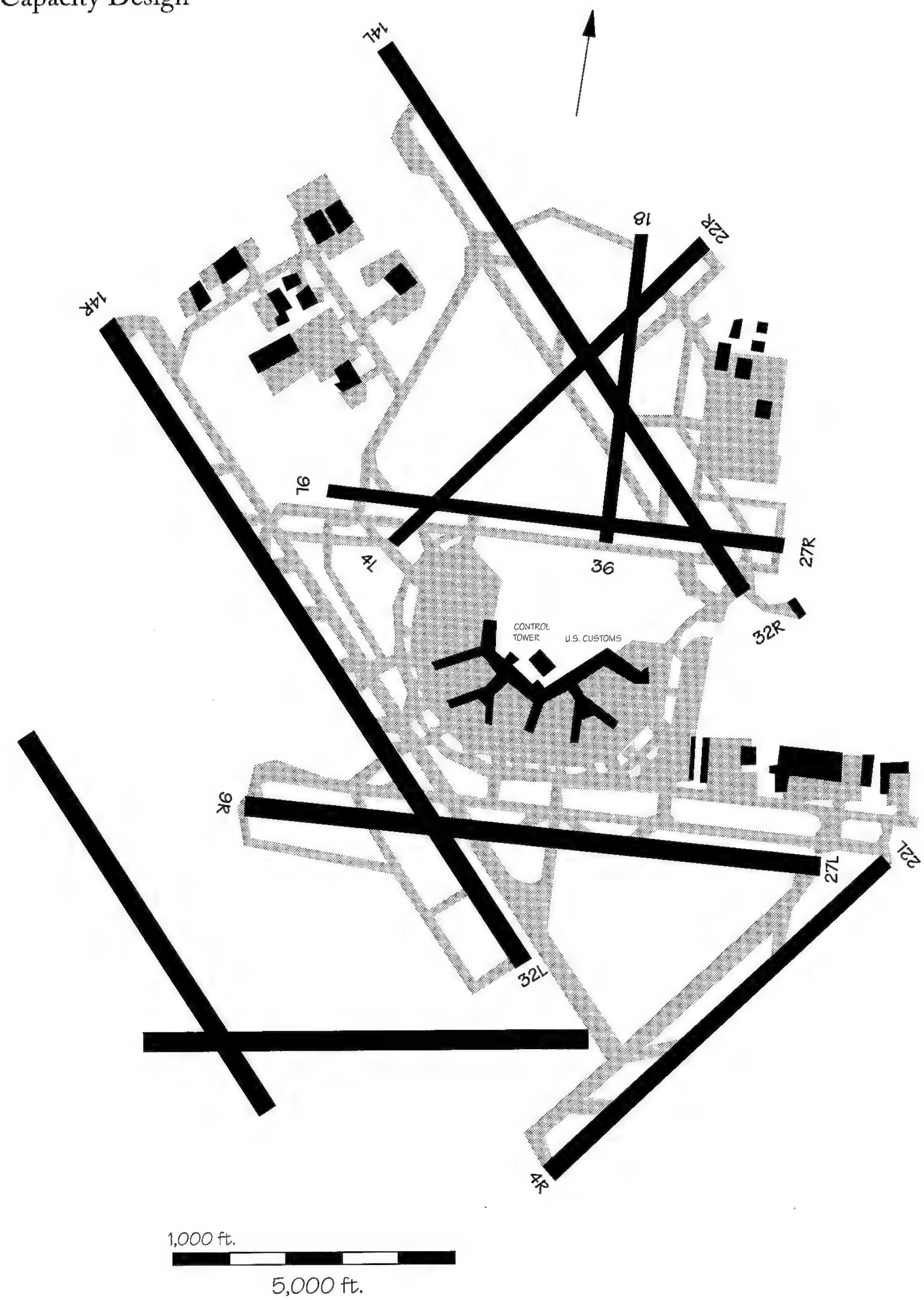
Charlotte/Douglas Int'l Airport (CLT)

Construction has been completed on the extension of Runway 18L/36R 1,000 feet to the south to provide simultaneous approach capability during noise abatement hours. Plans are to open a third parallel 8,000-foot runway west of Runway 18R/36L in 1999 that would permit dependent IFR arrivals. The Capacity Team also recommended the study of a fourth parallel runway east of 18L/36R. Dependent triple or quadruple IFR approaches could become available with the construction of this runway.



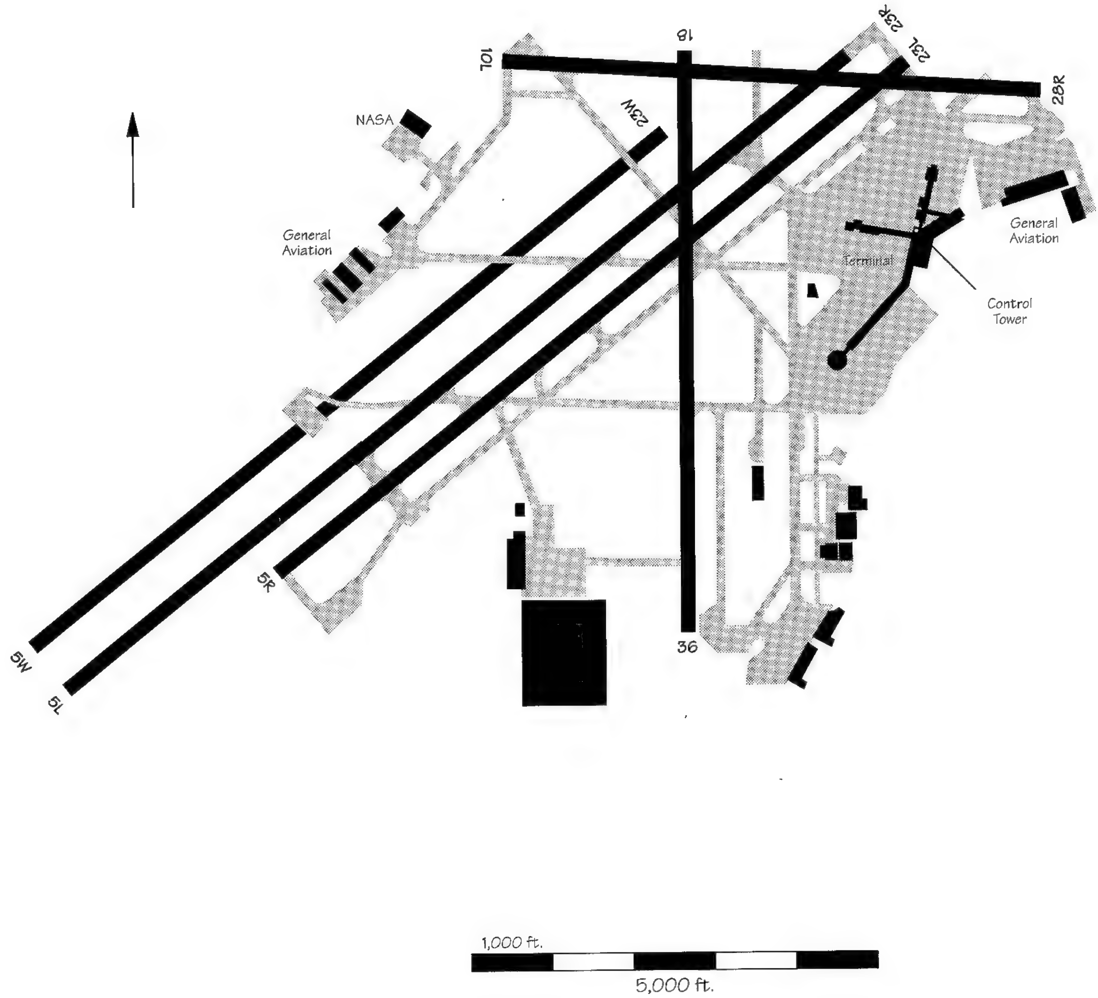
Chicago O'Hare Int'l Airport (ORD)

New air carrier Runways 9/27 and 14/32, extensions to Runways 14L and 22L, and the relocation of Runways 4L/22R and 9L/27R have been recommended by the Chicago Airport Capacity Design Team.



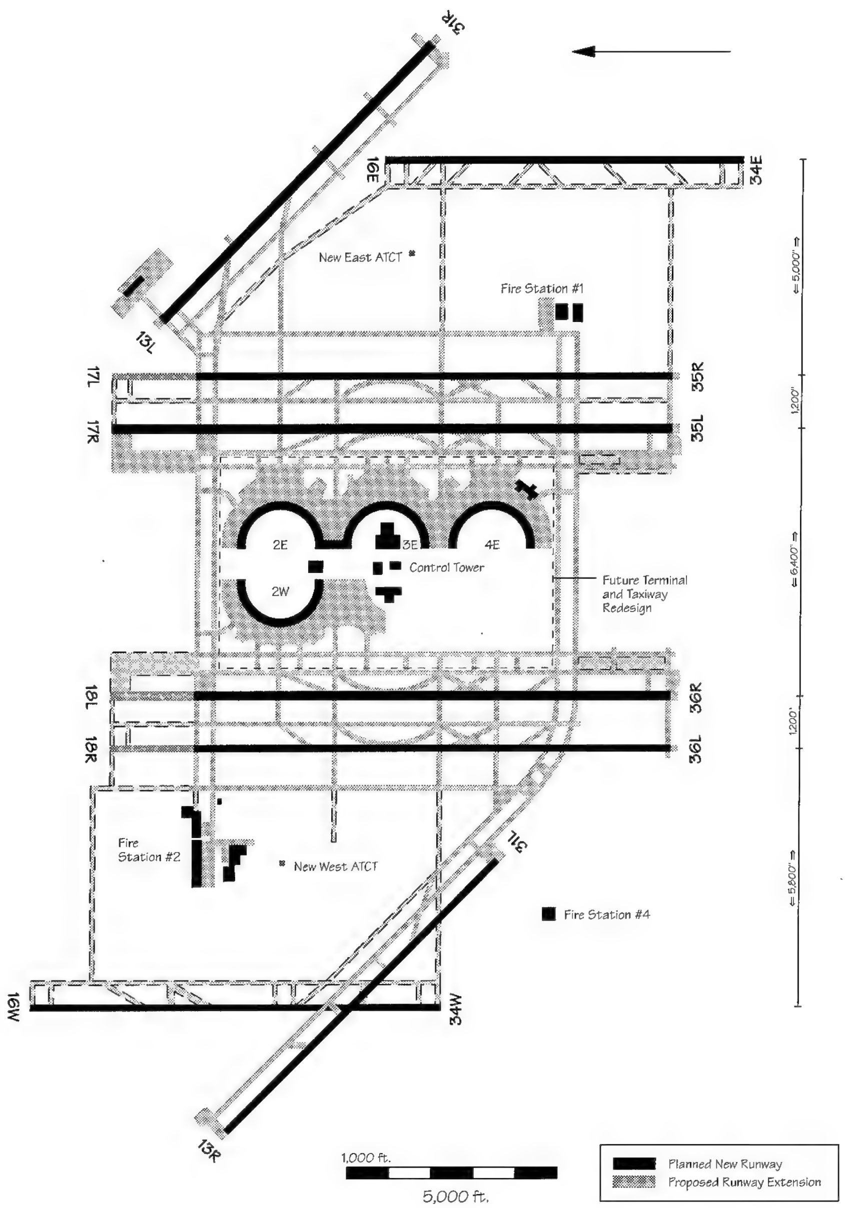
Cleveland Hopkins Int'l Airport (CLE)

A Master Plan Update is currently being coordinated. The preliminary Airport Layout Plan shows construction of a new Runway 5W/ 23W that would be 9,600 feet long and 150 feet wide. Construction is expected to be completed in 1997 at a cost of $125 million. Also included in the development plan is an extension of the existing Runway 5L/23R from 7,095 feet to 12,000 feet at an estimated cost of $50 million and conversion of the existing Runway 5R/23L to a parallel taxiway at a cost of $3 million. All of this work is scheduled for completion in 2000.



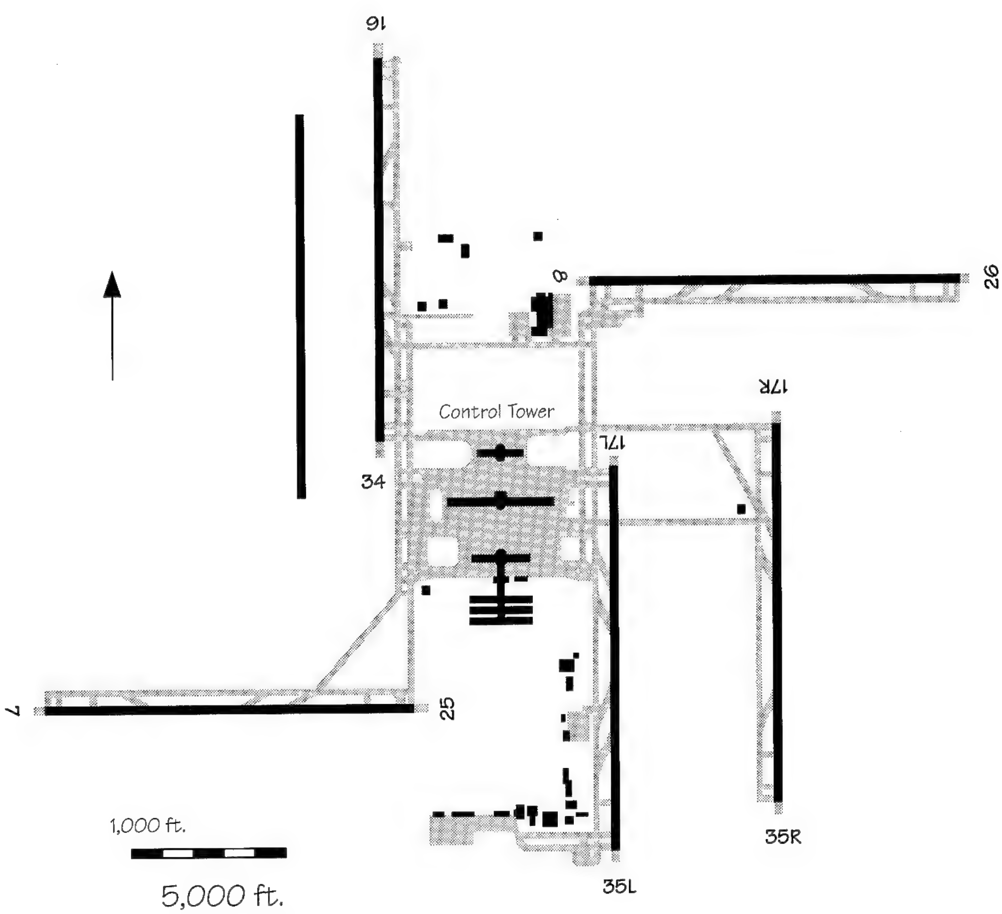
Dallas-Fort Worth Int'l Airport (DFW)

Proposed 2,000-foot extensions to all of the north/south parallel runways will provide an overall length of 13,400 feet for each. The estimated cost of each extension is $25 million. The extension of Runway 17R/35L has been completed and was operational September 16, 1993. Also planned are two more parallel runways, Runway 16L/34R and Runway 16R/34L. The east runway, Runway 16L/34R, will be 8,500 feet in length. It will be located 5,000 feet east of and parallel to Runway 17L/35R. The estimated cost is $320 million. It is anticipated that the east runway will be operational by 1996. Construction on the west runway, Runway 16R/34L, will begin when warranted by aviation demand. It could be available as early as 2001. The estimated cost is $150 million. It will be located 5,800 feet west of Runway 18R/36L. Runway 16R/34L may be constructed in phases, with the first phase a 6,000 foot runway located north of Runway 13R/31L. The second phase extension to 9,760 feet would intersect and continue south of Runway 13R/31L. These runways could potentially permit triple or quadruple IFR arrival operations (84 and 114 hourly IFR arrivals, respectively) if the multiple approach concepts are approved.



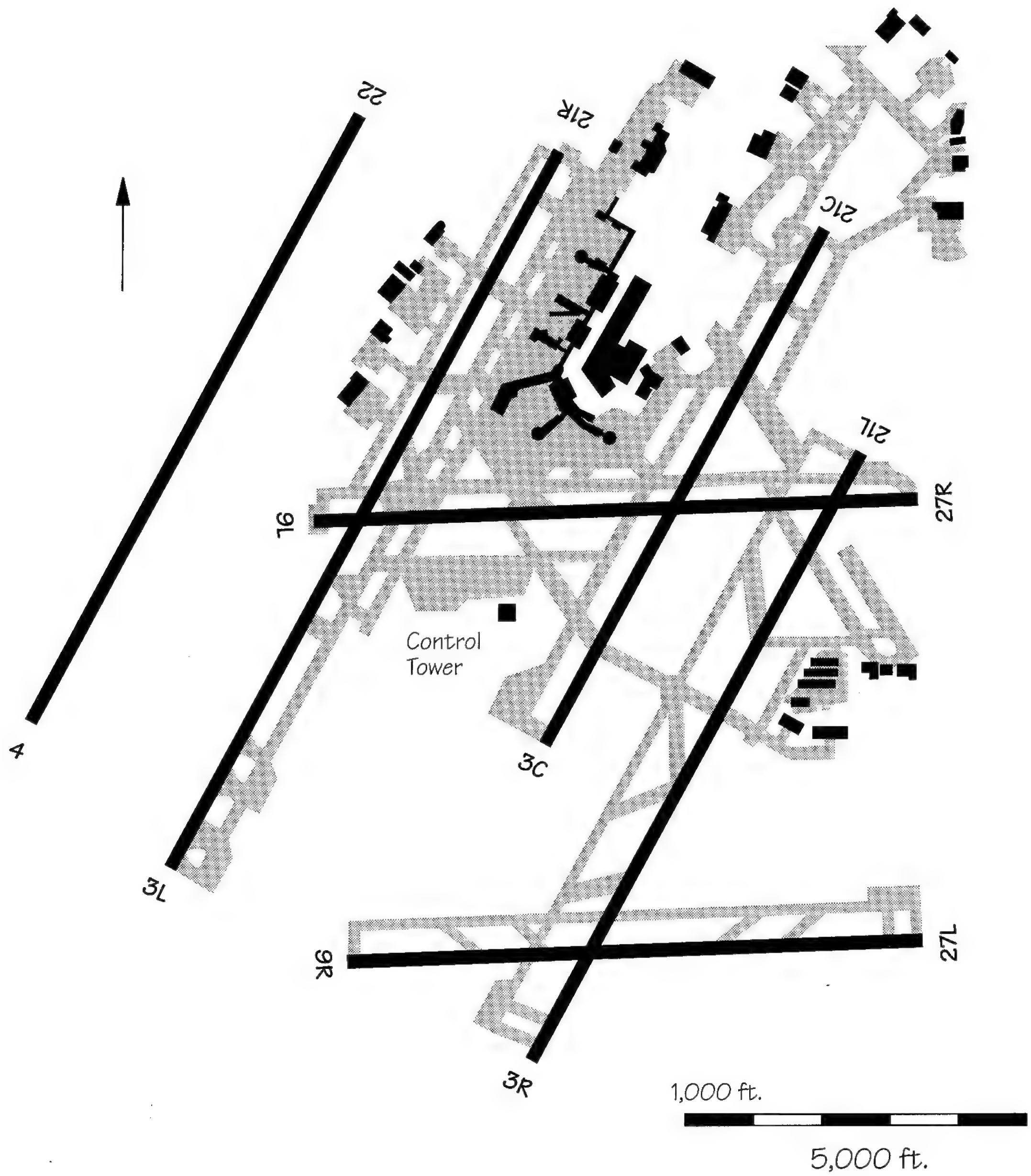
Denver Int'l Airport (DEN)

The initial phase of the new Denver airport will consist of five runways, with a sixth runway added a year after airport opening. The current plan involves four north-south parallels and two east-west parallels. Runway 16R/34L will initially be the farthest west of the four north-south parallels. It will be located 2,600 feet west of Runway 16L/34R and 10,200 feet west of Runway 17R/35L. Runway 17R/35L and Runway 17L/35R will be separated by 5,280 feet. East-west parallels, Runways 7L/25R and 8R/26L, will have centerlines 13,500 feet apart. Runway 7L/25R is south of Runways 16C/34C and 16L/34R. Runway 8R/26L is north of Runways 17R/35L and 17L/35R. Construction at the new airport began in late 1989. The total estimated cost of construction (exclusive of land acquisition and pre-1990 planning and administration costs) is $2.972 billion. The new airport is expected to be operational in 1995 and could potentially operate independent triple or quadruple IFR approaches, if they are approved. This could increase Denver's IFR arrival capacity from 57 to 86 per hour with triples or 114 per hour with quadruples. A second, future phase proposes the construction of up to six more runways.



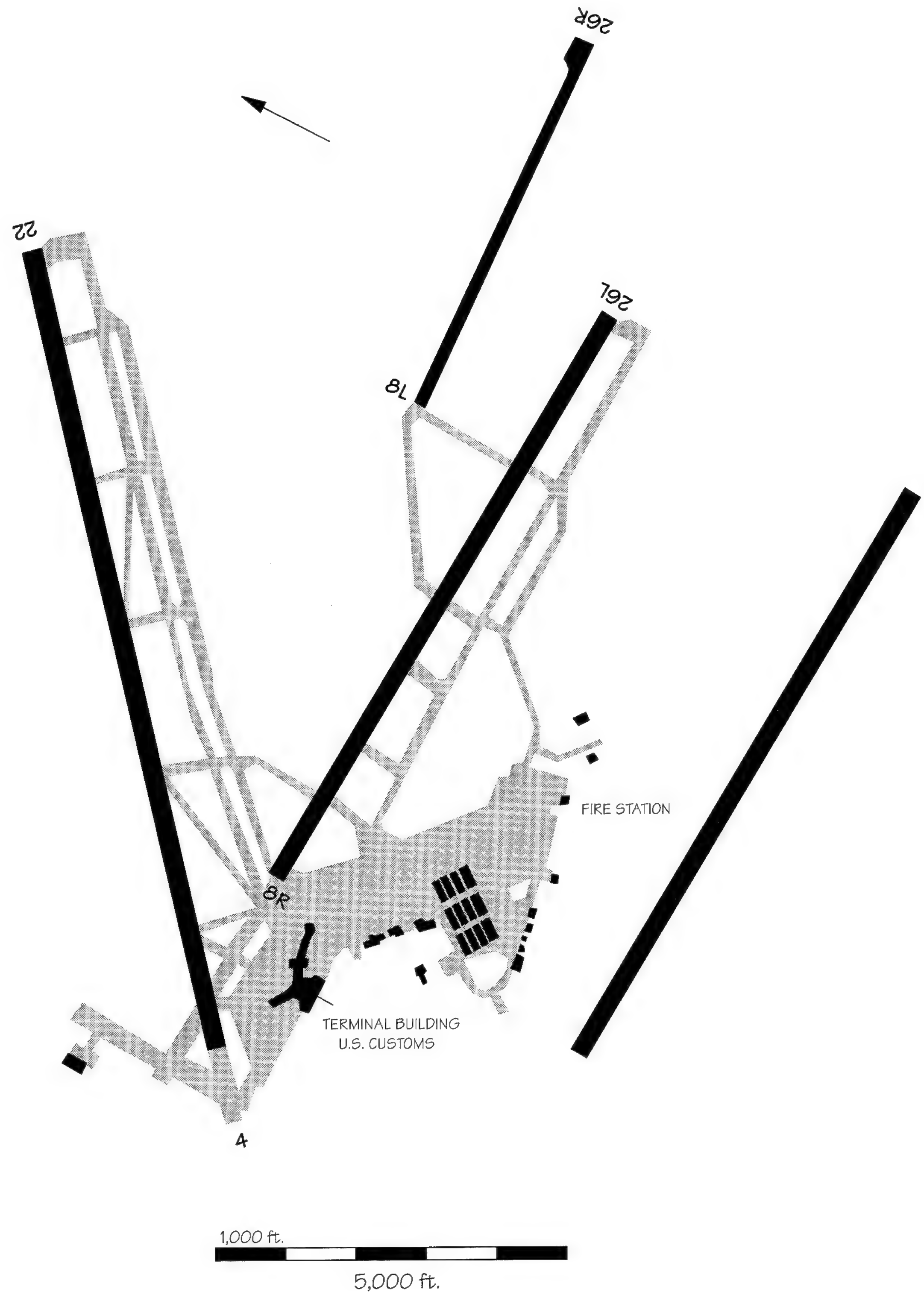
Detroit Metropolitan Wayne County Airport (DTW)

Construction of new Runway 9R/27L was completed in late 1993. The estimated cost of construction was $61.6 million. This new runway will allow DTW to run independent parallel IFR approaches in an east-west configuration, thus matching its current north-south IFR arrival capabilities. A fourth north-south parallel, Runway 4/22, 2,667 feet west of Runway 3L/21R, is also planned. Construction is expected to begin in 1996 and should be completed in 1998. The estimated cost of construction is $54.5 million. This runway could potentially permit triple IFR arrivals with one dependent and one independent pairing. If approved, hourly IFR arrival capacity could increase from 57 to 71. An environmental assessment was submitted in September 1989, and a record of decision was issued in March 1990.



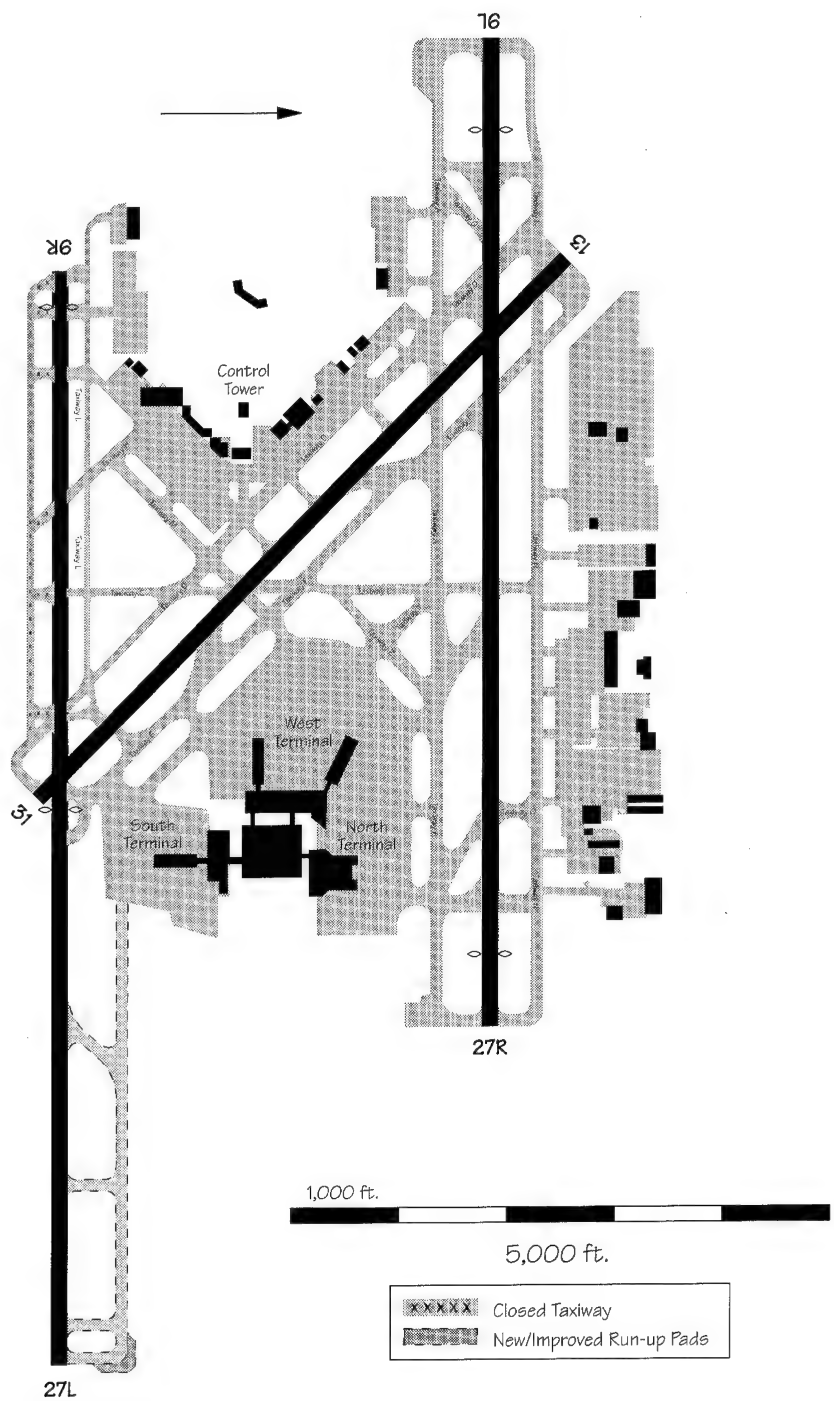
El Paso Int'l Airport (ELP)

A new parallel Runway 8/26 is planned. Construction is expected to begin in 1999 with an estimated cost of $10.7 million.



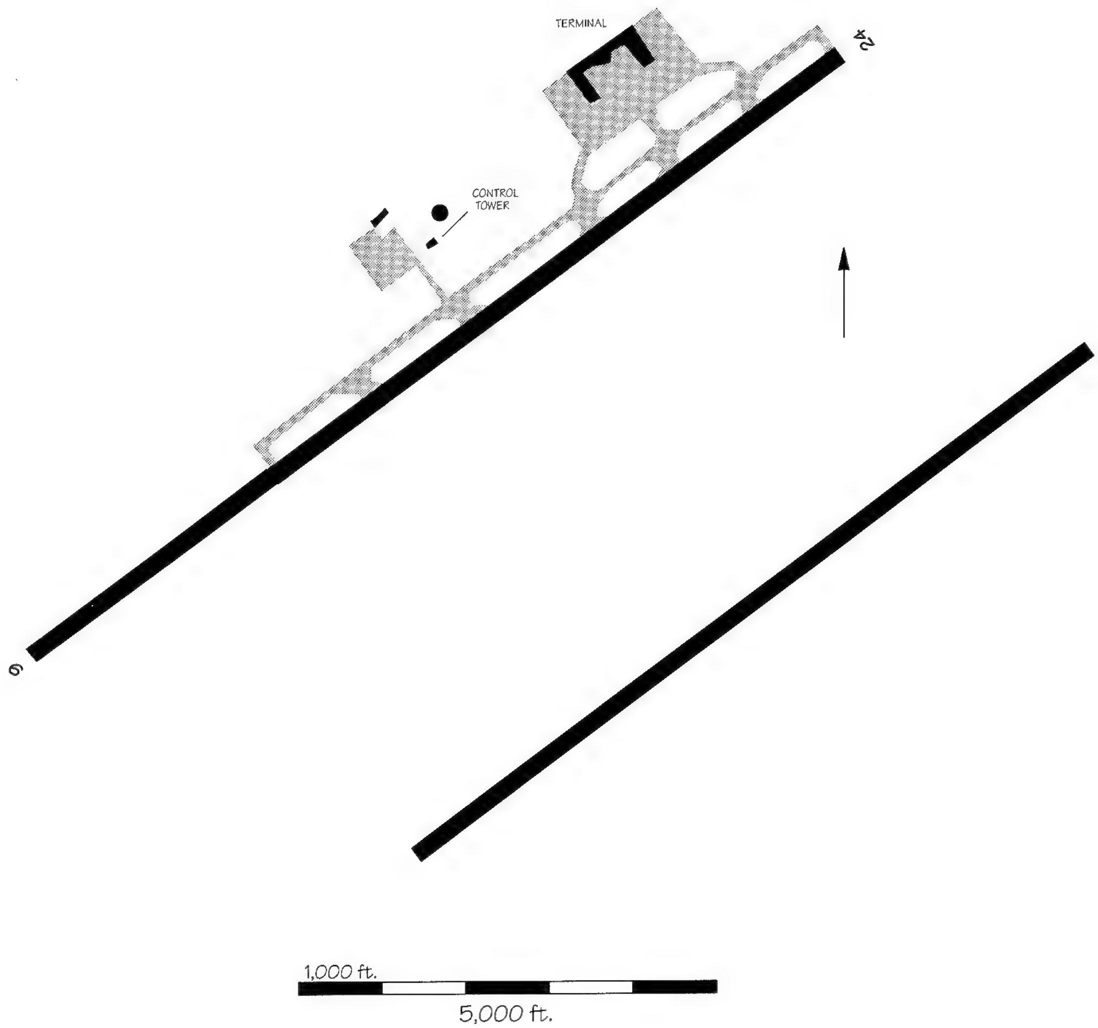
Ft. Lauderdale-Hollywood Int'l Airport (FLL)

An extension of the short parallel Runway 9R/27L to 10,000 feet long by 150 feet wide is planned to provide the airport with a second parallel air carrier runway. Construction is expected to begin in 1997. The estimated cost of construction is $270 million. The anticipated operational date is 2000.



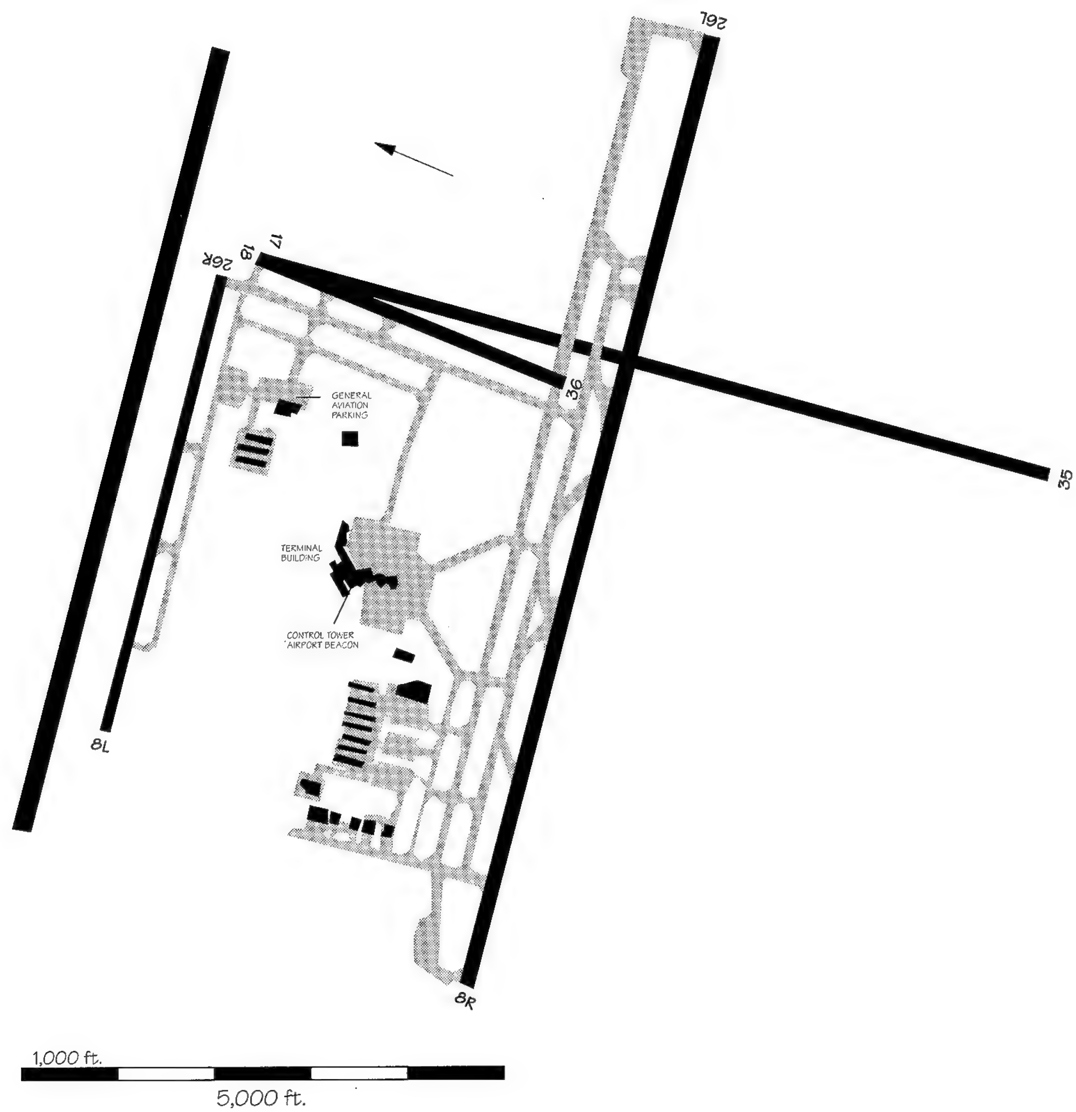
Ft. Myers Southwest Florida Regional Airport (RSW)

Planning has begun for a new 9,000 to 10,000 foot parallel runway, Runway 6R/24L, 4,300 feet or more southeast of Runway 6/24. Construction is expected to begin in 1998. The new runway should be operational by 2000. The estimated cost of the project is $87 million. This new runway will support independent parallel operations, with the potential to increase IFR hourly arrival capacity from 29 to 57. Construction of an extension to Runway 6/24 from 8,400 feet to 12,000 feet began July 14, 1993. The estimated cost of the extension is $20 million, and the estimated operational date is October 1994.



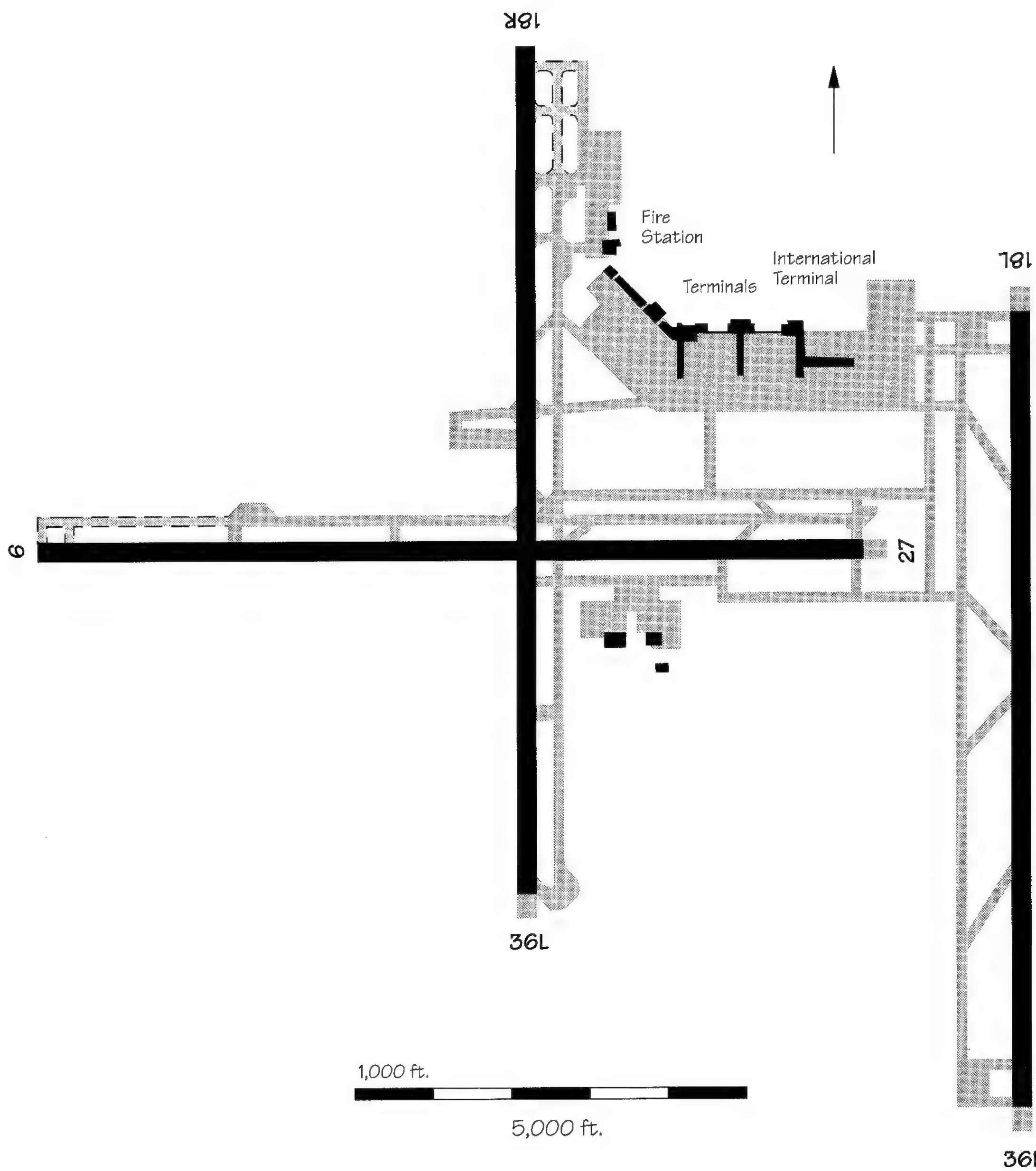
Grand Rapids Kent County Int'l Airport (GRR)

An extension of the existing Runway 8L/26R to 5,000 feet is under construction and will be completed in 1994. Estimated cost of construction is $3.6 million. In the long-range plan, this runway will be converted into a taxiway for a new 7,000 foot Runway 8L/26R. An extension to 8,500 feet and realignment are planned for the cross-wind Runway 18/36 (17/35). The project is expected to start in 1994. Estimated cost of construction is $40 million. The runway will provide wind coverage, noise relief, and reduce winter weather related delays by providing a second air carrier runway. Airport Layout Plan (ALP) and Environmental approvals for these projects were completed in January 1993.



Greater Cincinnati Int'l Airport (CVG)

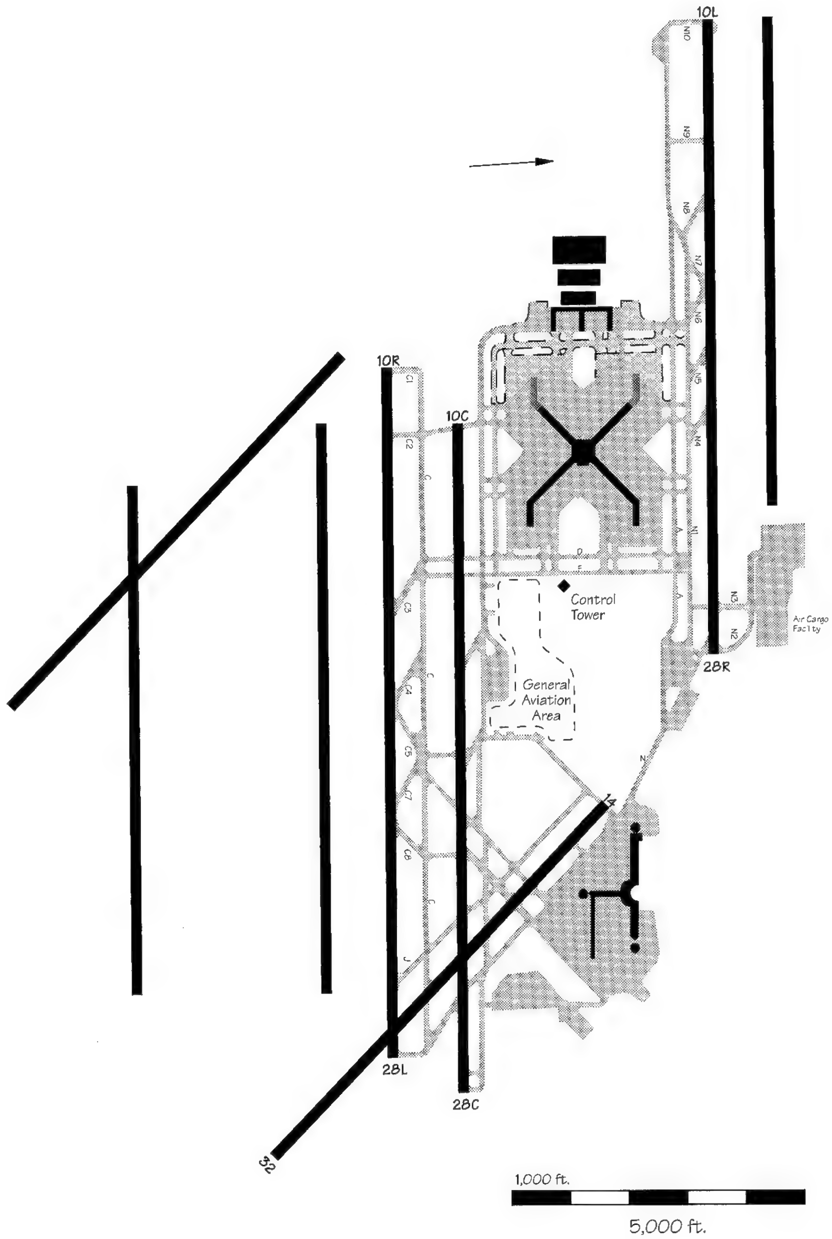
An extension of Runway 18R/36L has been proposed to allow all aircraft to land on Runway 18R and hold short of Runway 27 and to add capacity during noise abatement hours. The estimated cost of construction is $11 million, and the estimated operational date is 1997. An extension of Runway 9/27 is under construction, with an estimated operational date of 1995 and a cost of $20 million, with an additional $5 million to reconstruct the intersection of Runways 9/27 and 18R/36L. This runway will increase capacity during night-time noise abatement operations.



Greater Pittsburgh Int'l Airport (PIT)

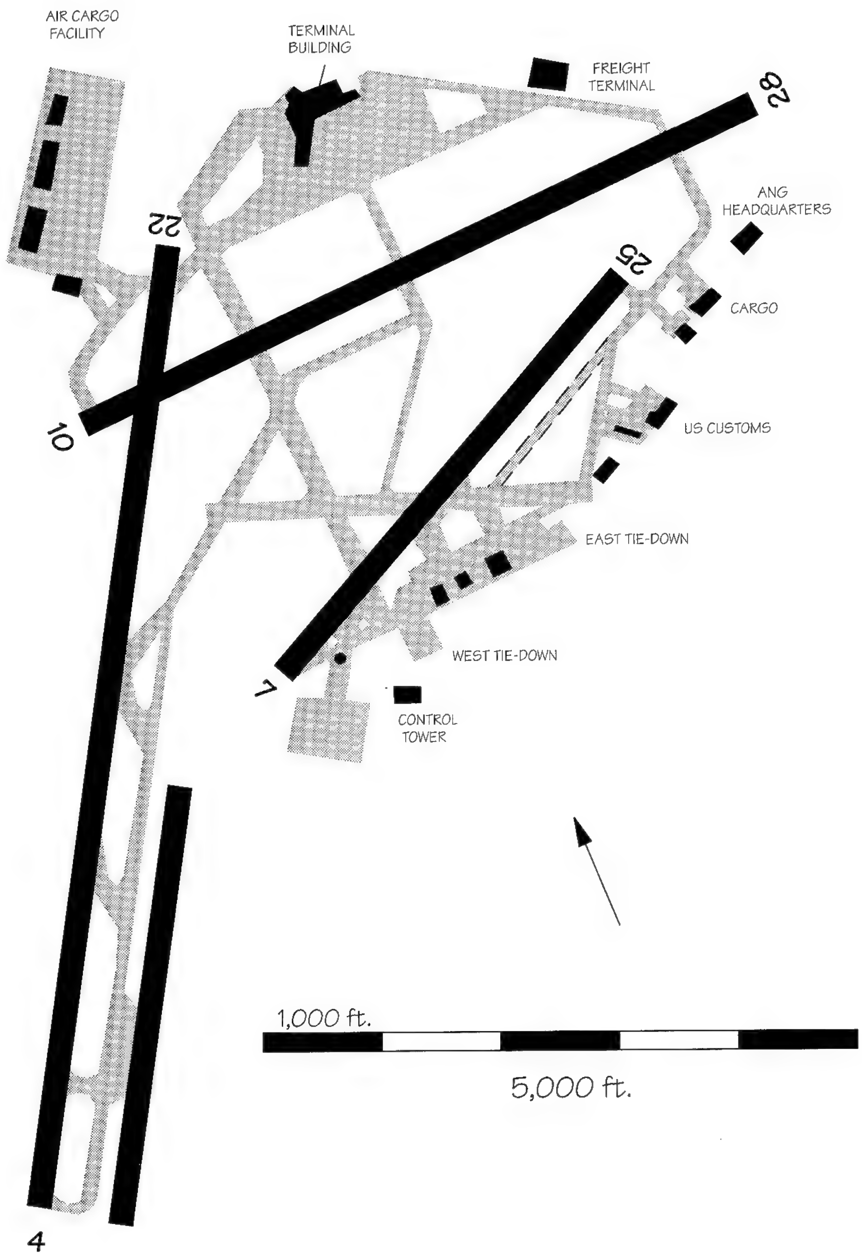
A recently completed Master Plan has recommended that at least two new runways will be needed within a twenty year planning period to accommodate projected Baseline (normal growth) forecast demands and achieve acceptable aircraft delay times and associated delay costs. Construction of the two east/west runways include a northern parallel and a southern parallel, with the latter as the preferred first-build runway. The southern parallel will be located approximately 4,300 feet south of existing Runway 10R/28L and should be operational by the time the airport reaches 495,000 annual aircraft operations.

The northern parallel runway will be located 1,000 feet north of existing Runway 10L/28R and should be operational by the time the airport reaches 522,000 annual aircraft operations. Should forecasts exceed Baseline demands the airport has identified two additional runway options including a close-in south parallel runway located 1,000 feet south of existing Runway 10R/28L and a crosswind runway located 8,700 feet from the existing crosswind Runway 14/32. An environmental Impact Statement is currently being prepared for the development of the fifth runway.



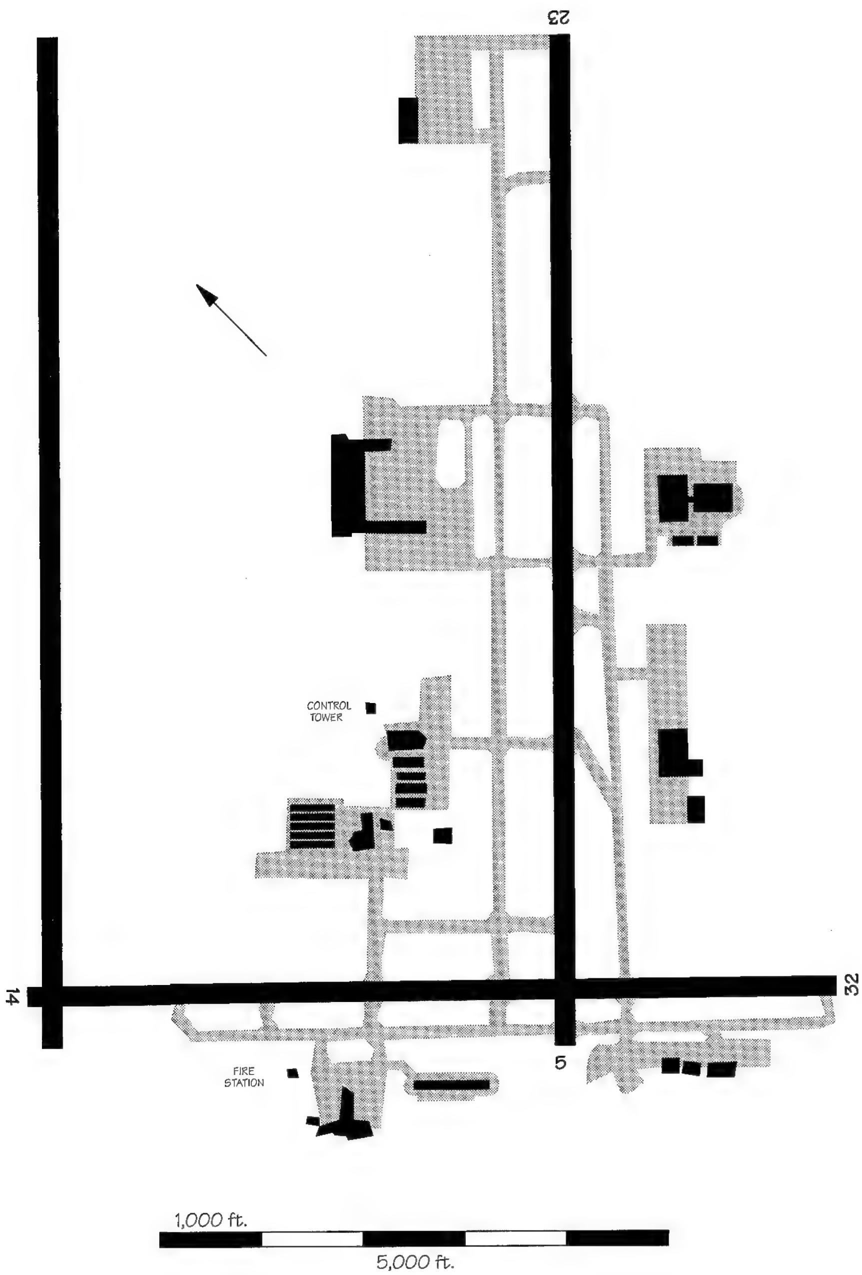
Greater Rochester Int'l Airport (ROC)

Construction of an extension to Runway 10/28 is being considered. The estimated cost of construction is $3.2 million. An extension to Runway 4/22 is also being considered, and is expected to cost $4 million. Construction of a new parallel Runway 4R/22L 700 feet southeast of Runway 4/22 is estimated to cost $10 million. These runway improvements are anticipated post 2000. Environmental assessments have not yet been started for these projects.



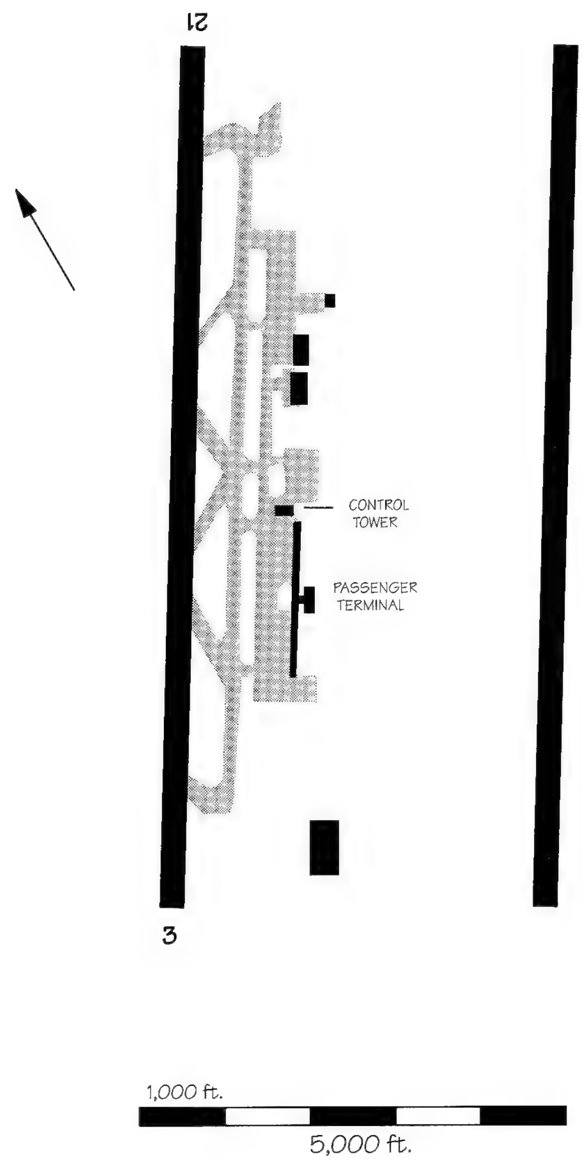
Greensboro Piedmont Triad Int'l Airport (GSO)

An extension of Runway 14/32 is planned. It is expected to be operational by 1998, at a cost of $15.7 million. Construction of a new parallel Runway 5L/23R 5,300 feet north of Runway 5/23 is also being planned.



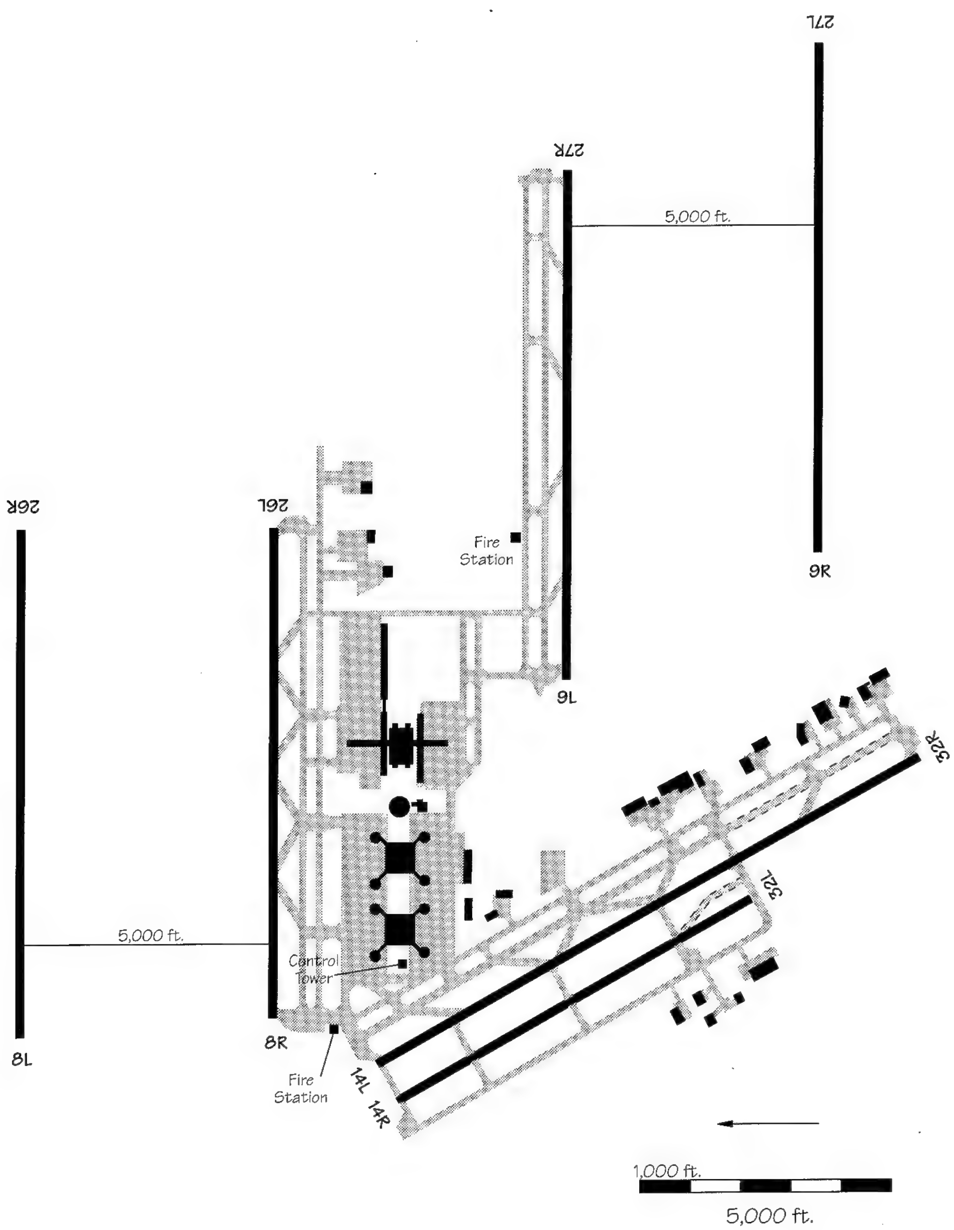
Greer Greenville-Spartanburg Airport (GSP)

A new parallel runway, Runway 3R/21L, is anticipated in 2015 at an estimated cost of $50 million. Presently, its planned length is 10,000 feet with a 4,300 foot separation from Runway 3/21. This would potentially double hourly IFR arrival capacity from 29 to 57. Also, an extension of Runway 3L/21R to 10,000 feet is planned. Construction is expected to be completed in 1999 at a cost of $34.1 million.



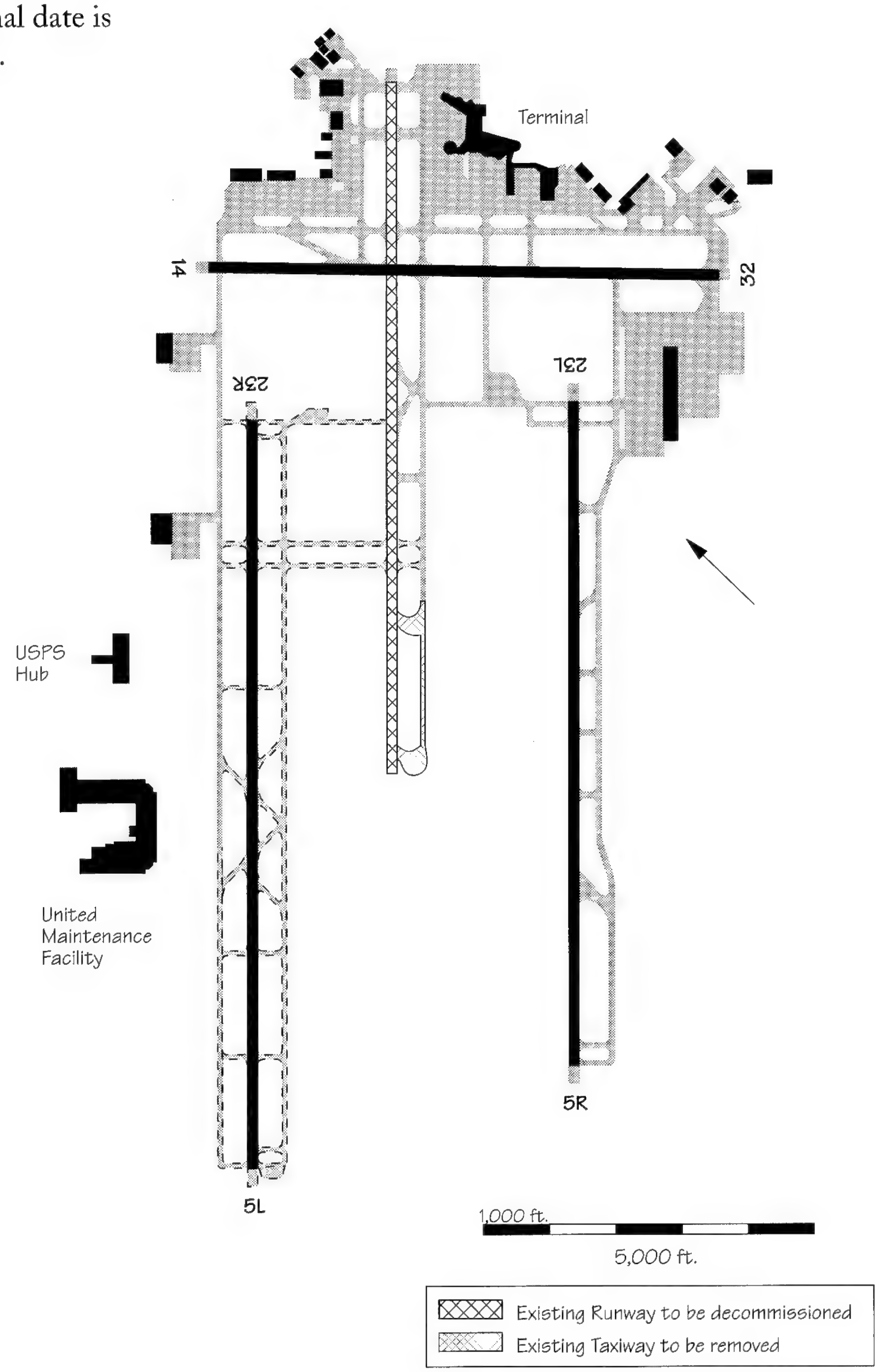
Houston Intercontinental Airport (IAH)

An $8 million 2,000-foot extension to Runway 14R/32L is planned to be operational in 1997. Construction is expected to begin in 1996. A new Runway 8L/26R is planned to be completed in 1999. Construction should begin in 1997 and is estimated to cost $44 million. This runway will be parallel to and north of the existing Runway 8/26. Runway 8L/26R, in conjunction with Runways 9/27 and 8/26, has the potential to support triple IFR approaches, if approved. Another new runway, parallel to and south of Runway 9/27 is also planned. Construction is expected to cost $44 million.



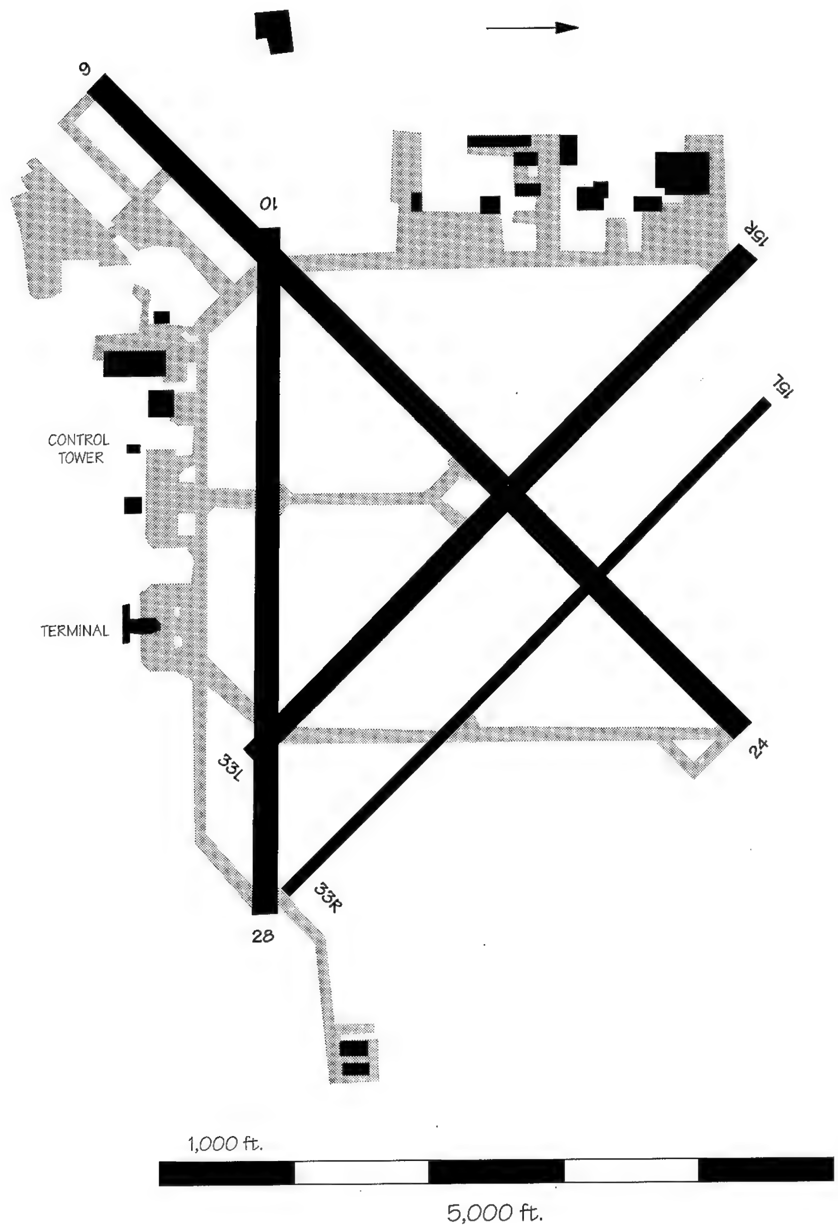
Indianapolis Int'l Airport (IND)

Construction of a replacement for Runway 5L/23R 4,800 feet northwest of Runway 5R/23L began on January 22, 1993, and is scheduled to be completed in 1995. The estimated total project cost is $37.5 million, and the estimated operational date is December 1995.



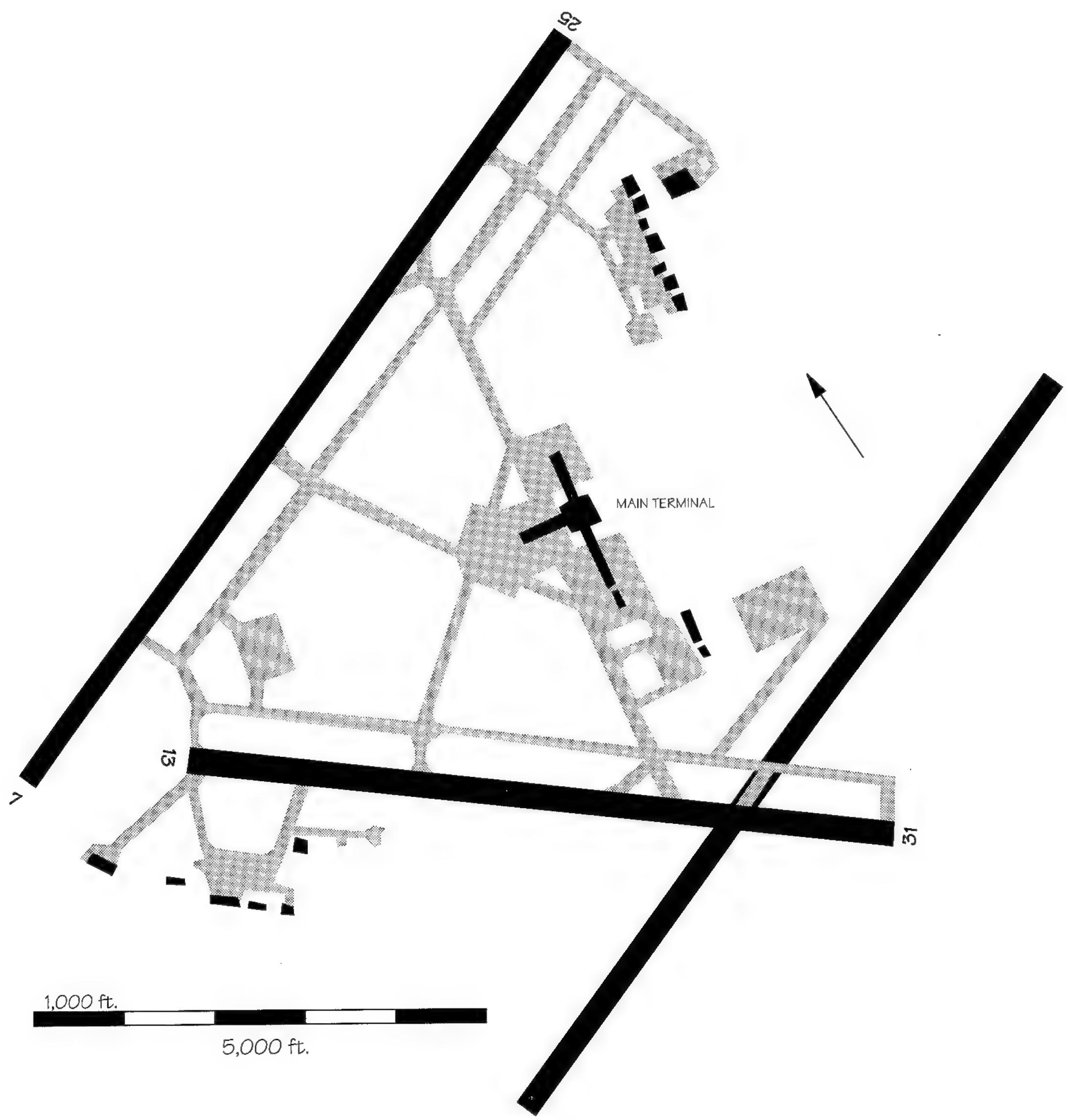
Islip Long Island Mac Arthur Airport (ISP)

An extension of Runway 15R/33L is planned for 2000. The estimated cost of construction is $26 million.



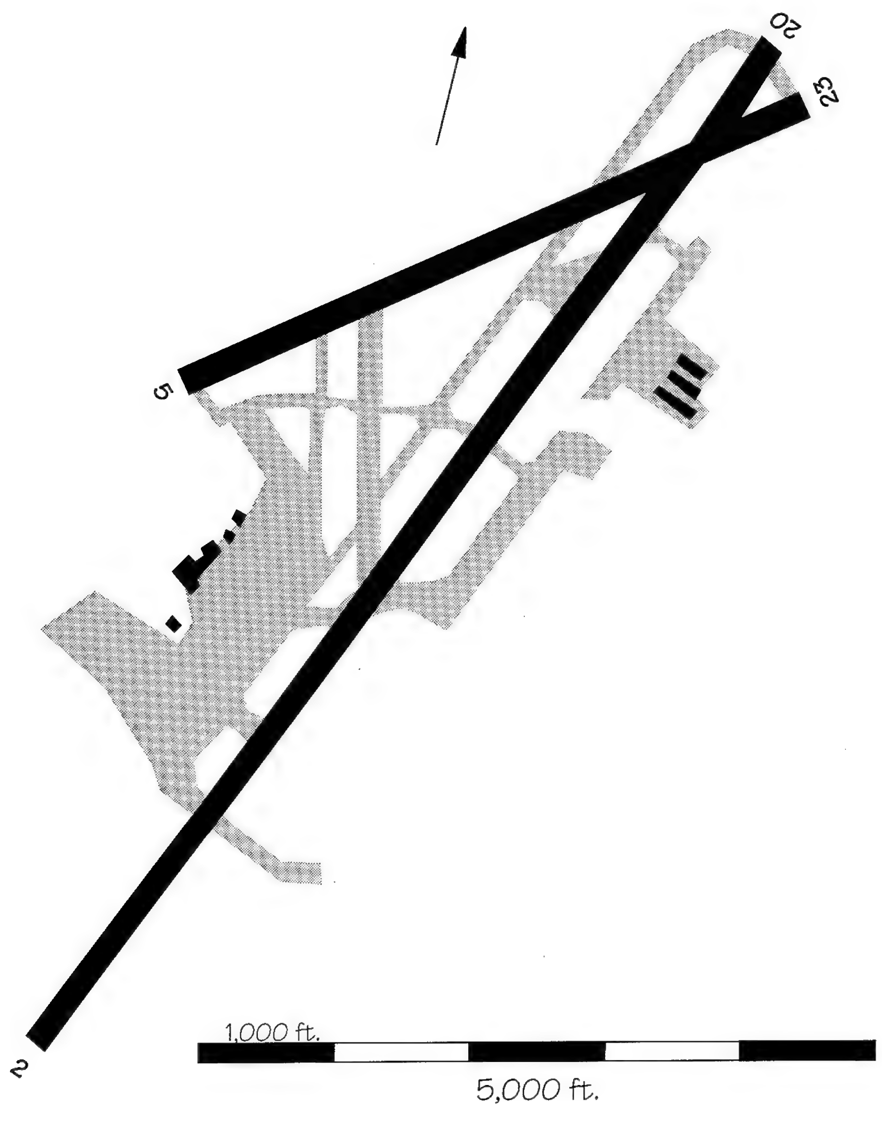
Jacksonville Int'l Airport (JAX)

Construction began March 20, 1993 of an extension to Runway 7/25, with an expected operational date of September 1994. The estimated project cost is $19 million. A new parallel Runway 7R/25L is also being planned. It will be 6,500 feet south of the existing Runway 7/25, permitting independent parallel IFR operations and potentially doubling Jacksonville's hourly IFR arrival capacity. Construction is scheduled to begin in 1999, with completion expected in 2000. Estimated cost of construction is $37 million.



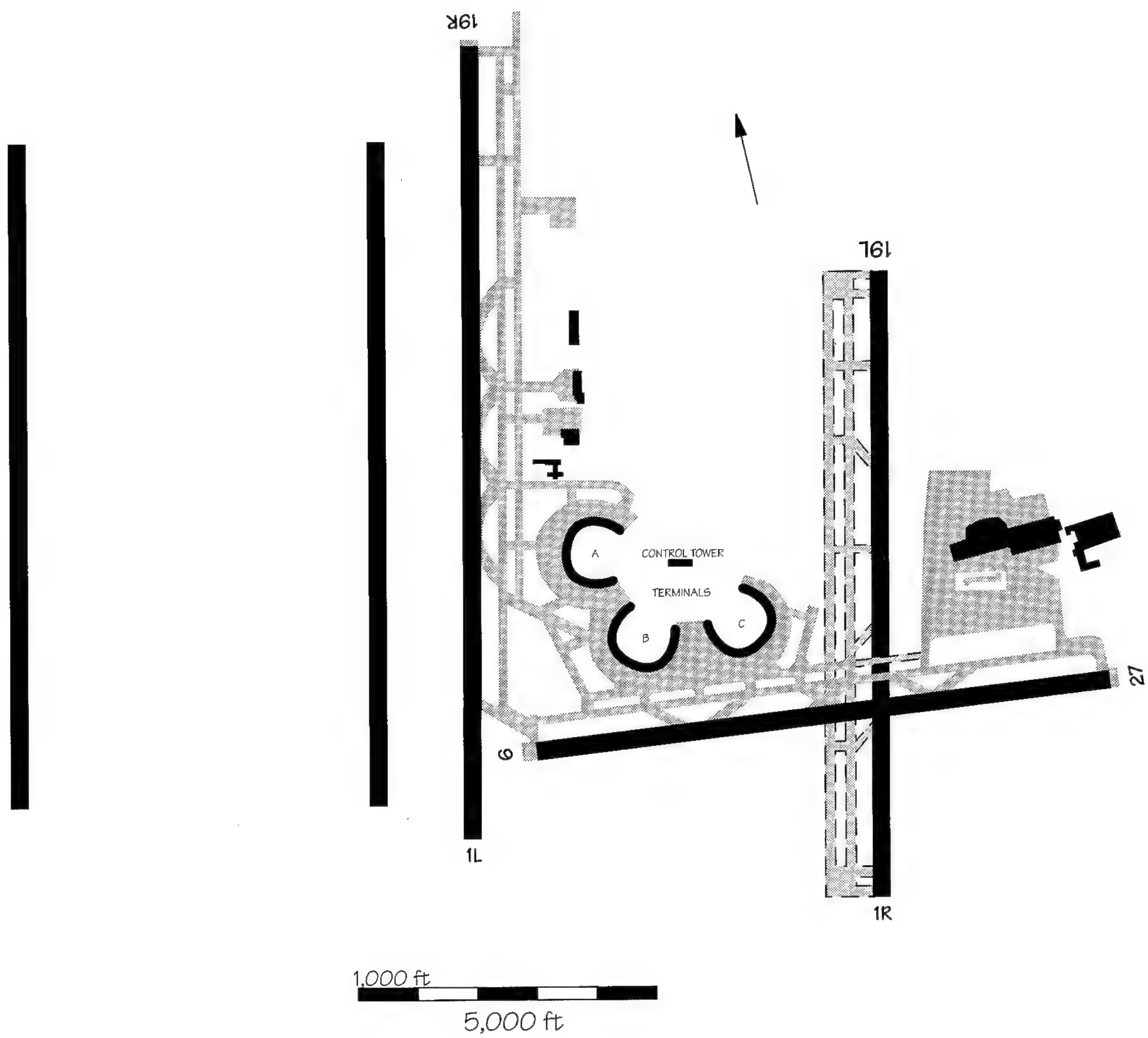
Kahului Airport (OGG)

An extension of Runway 2/20 is being planned.



Kansas City Int'l Airport (MCI)

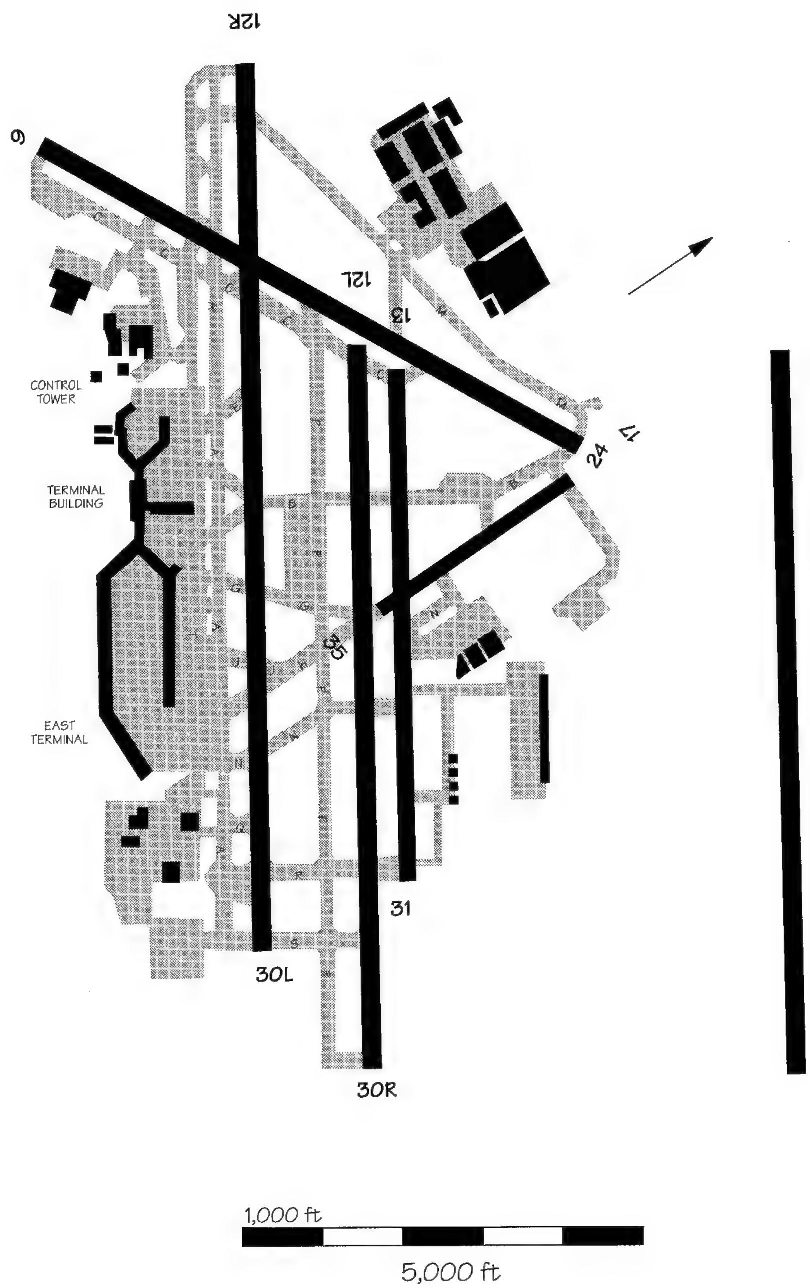
Construction began on the new north-south parallel Runway 1R/19L in October 1989. It it located 6,575 feet east of the existing Runway 1L/19R and will permit independent IFR operations. The runway should be operational in November 1994. The estimated cost of construction is $45.2 million. In the Airport Master Plan currently underway an extension of Runway 1L/19R and additional parallel runways west of the existing north-south runway are being considered.



Lambert St. Louis Int'l Airport (STL)

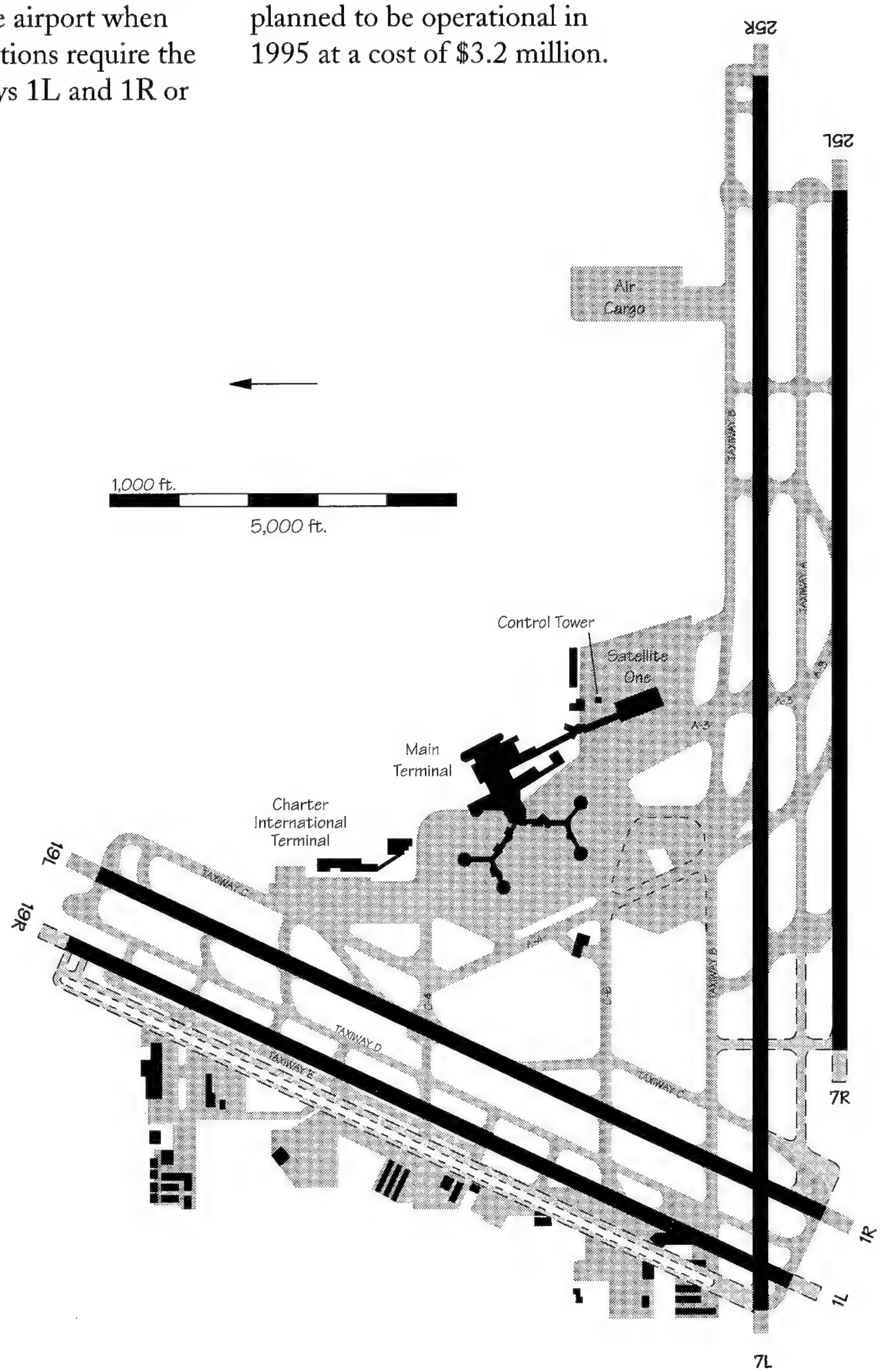
A new parallel Runway 12L/30R in several configurations had been recommended by the St. Louis Airport Capacity Design Team. A Master Plan Update is underway, and the entire airport layout may change as a result. The new plan will probably call for three parallel runways, with at least two supporting independent IFR operations. An EIS is also underway. The Master Plan Update and the EIS are anticipated to be completed by December 1995.

A new Runway 14R/32L is planned as the first phase of the airport expansion. Construction of the runway could occur beginning in 1996, subject to environmental approval.



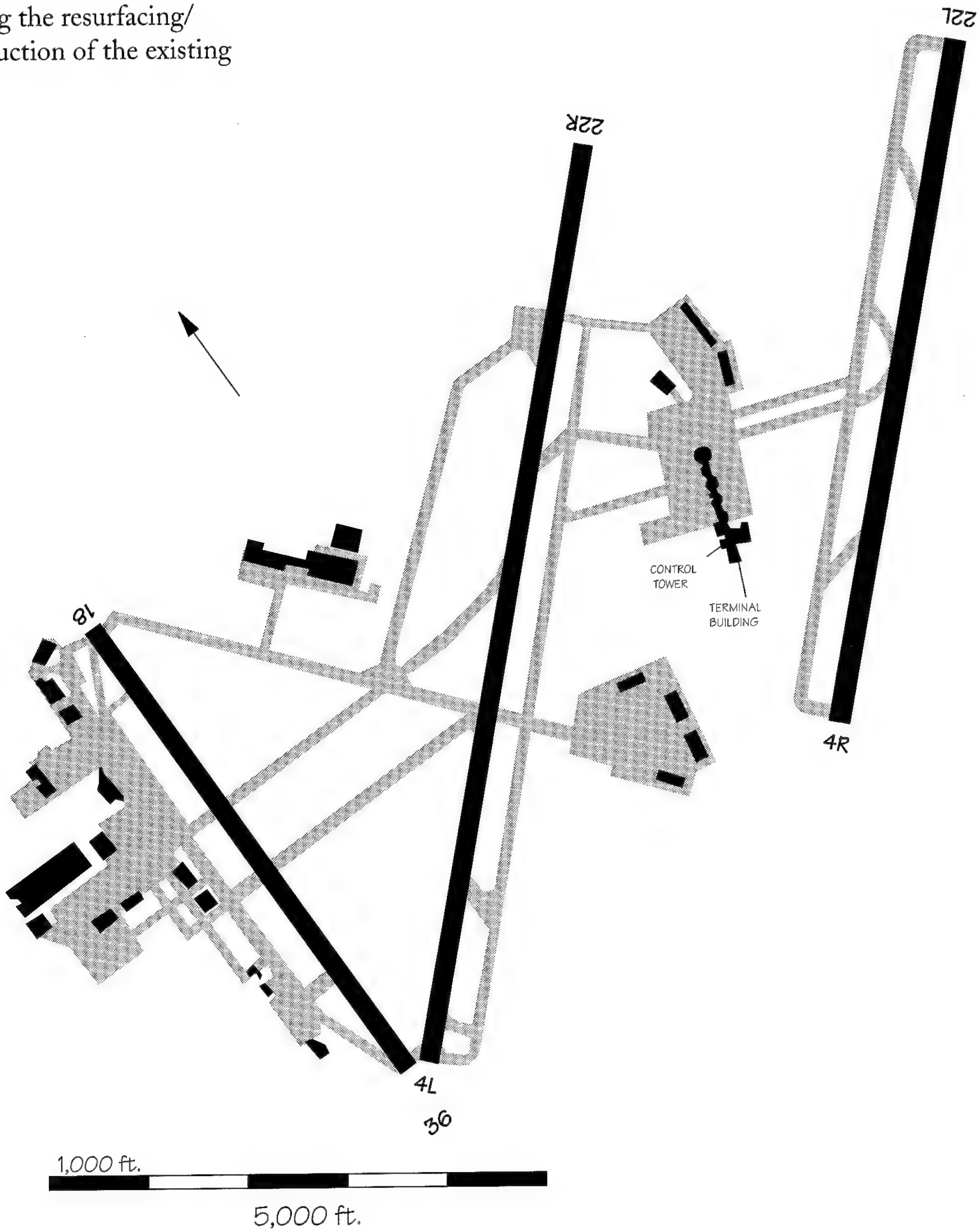
Las Vegas McCarran Int'l Airport (LAS)

An upgrade of Runway 1L/19R to accommodate air carrier aircraft is being planned for 1997. This improvement will significantly increase the capacity of the airport when weather conditions require the use of Runways 1L and 1R or 19L and 19R. An extension of Runway 7L/25R has been completed, at a cost of $17.5 million. An extension of Runway 7R/25L is also planned to be operational in 1995 at a cost of $3.2 million.



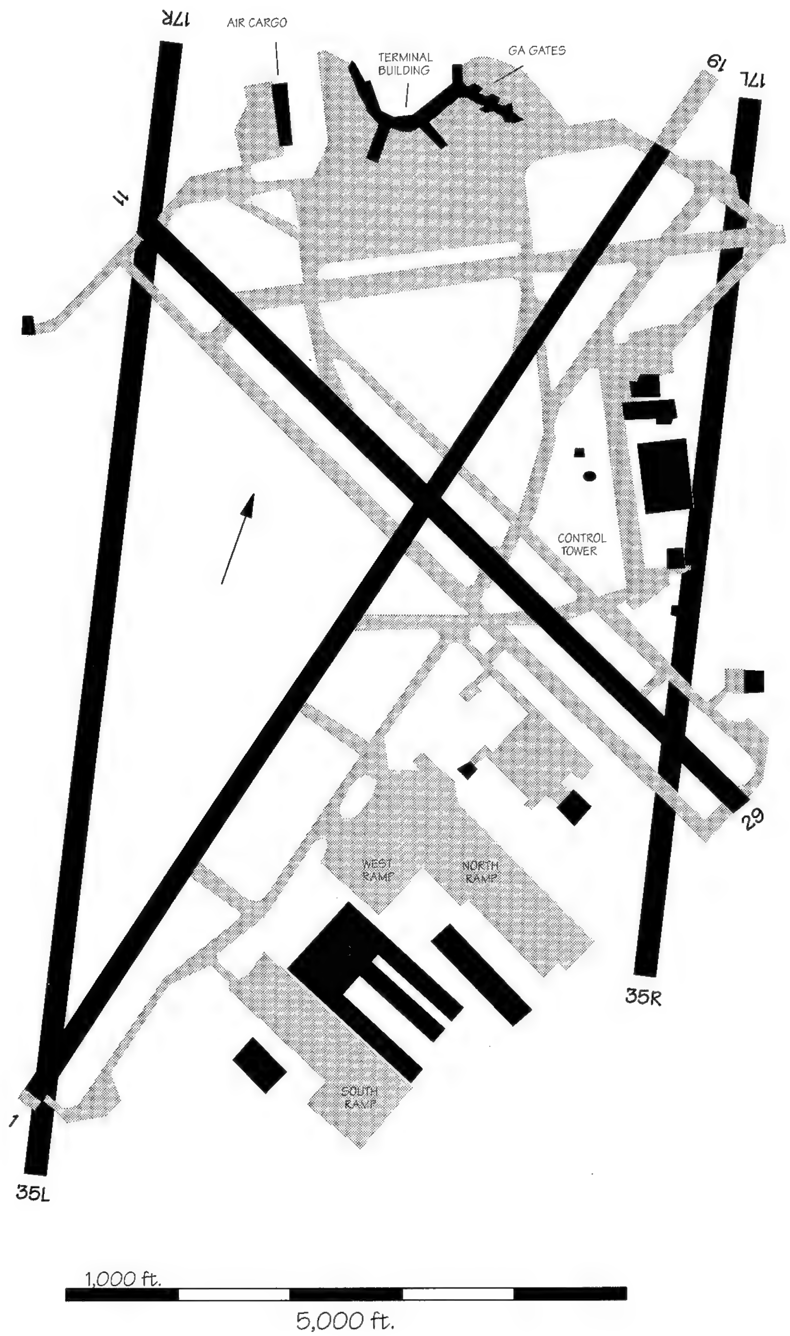
Little Rock Adams Field (LIT)

An extension to Runway 4L/22R is scheduled to begin construction in 1994 and should be operational in 1996. The estimated cost of construction is $30 million, including the resurfacing/reconstruction of the existing runway.



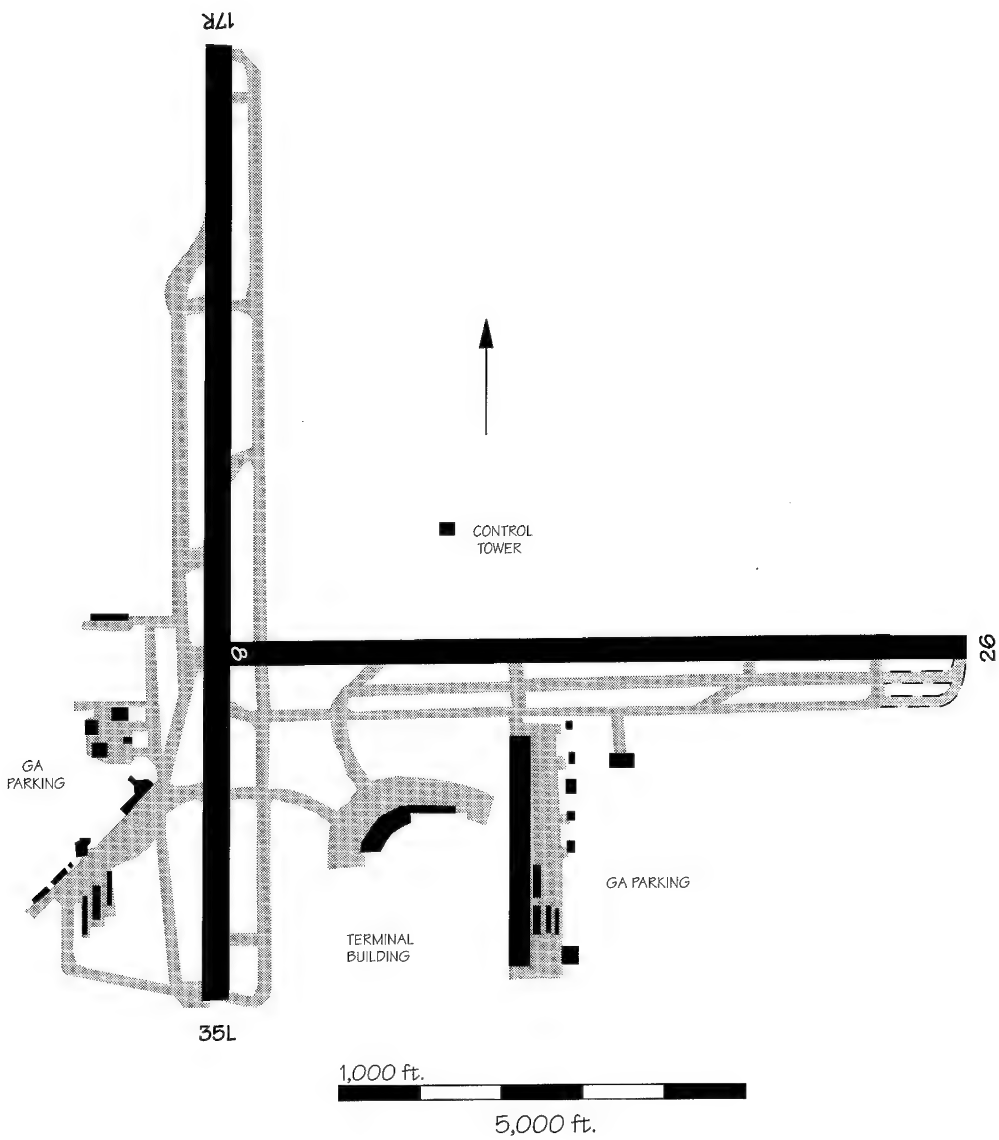
Louisville Standiford Field (SDF)

Construction is underway for two new parallel runways, 4,950 feet apart. They will be numbered Runways 17R/35L and 17L/35R and will be 10,000 and 7,800 feet long, respectively. They will replace Runway 1/19, which will be closed. The estimated cost of construction is $51 million for Runway 17R/35L and $42 million for 17L/35R. Runway 17L/35R is expected to be completed in 1995, and Runway 17R/35L is expected to be completed in 1997. The two runways will permit independent parallel IFR operations and increase hourly IFR arrival capacity from 29 to 57.



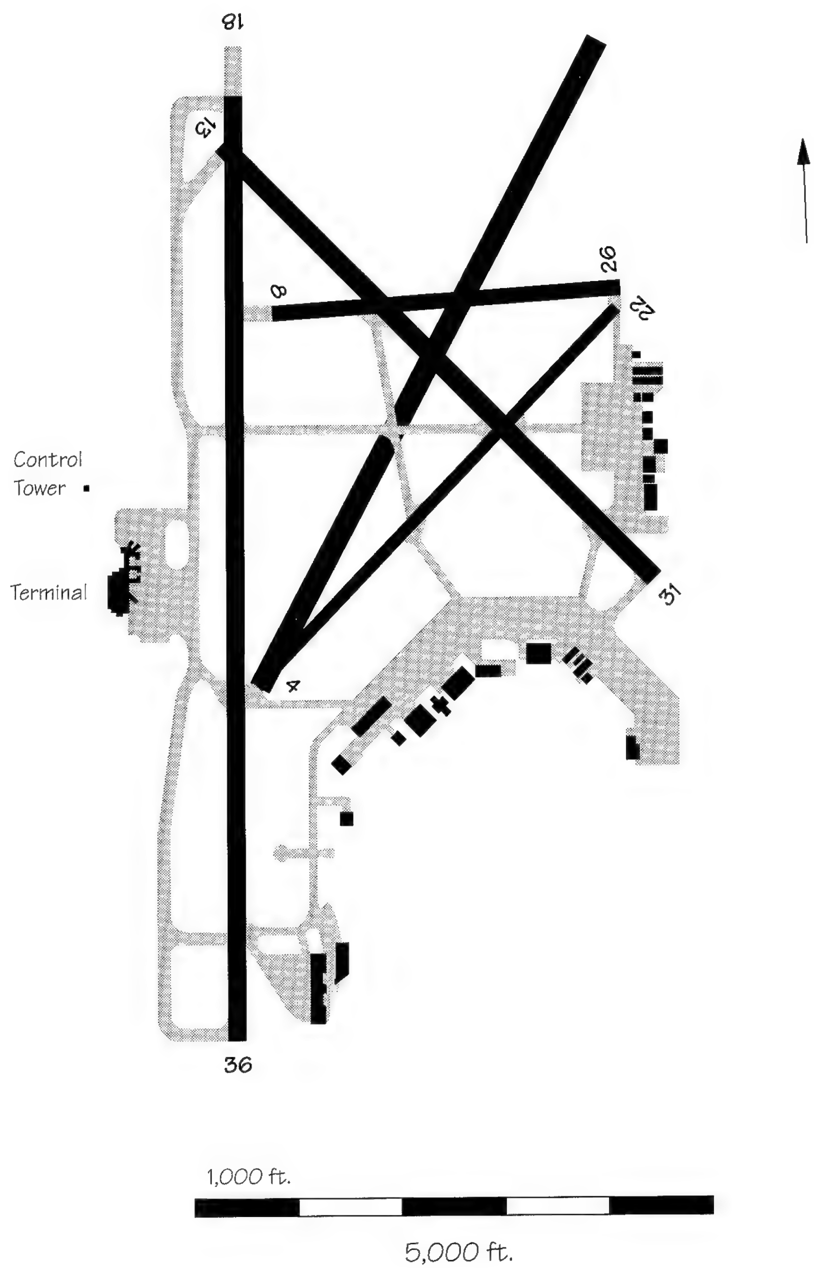
Lubbock Int'l Airport (LBB)

An extension to Runway 8/26 is planned. The start of construction is scheduled for 2000 and the estimated cost is $3.8 million. It is anticipated that the extension will be operational in 2000.



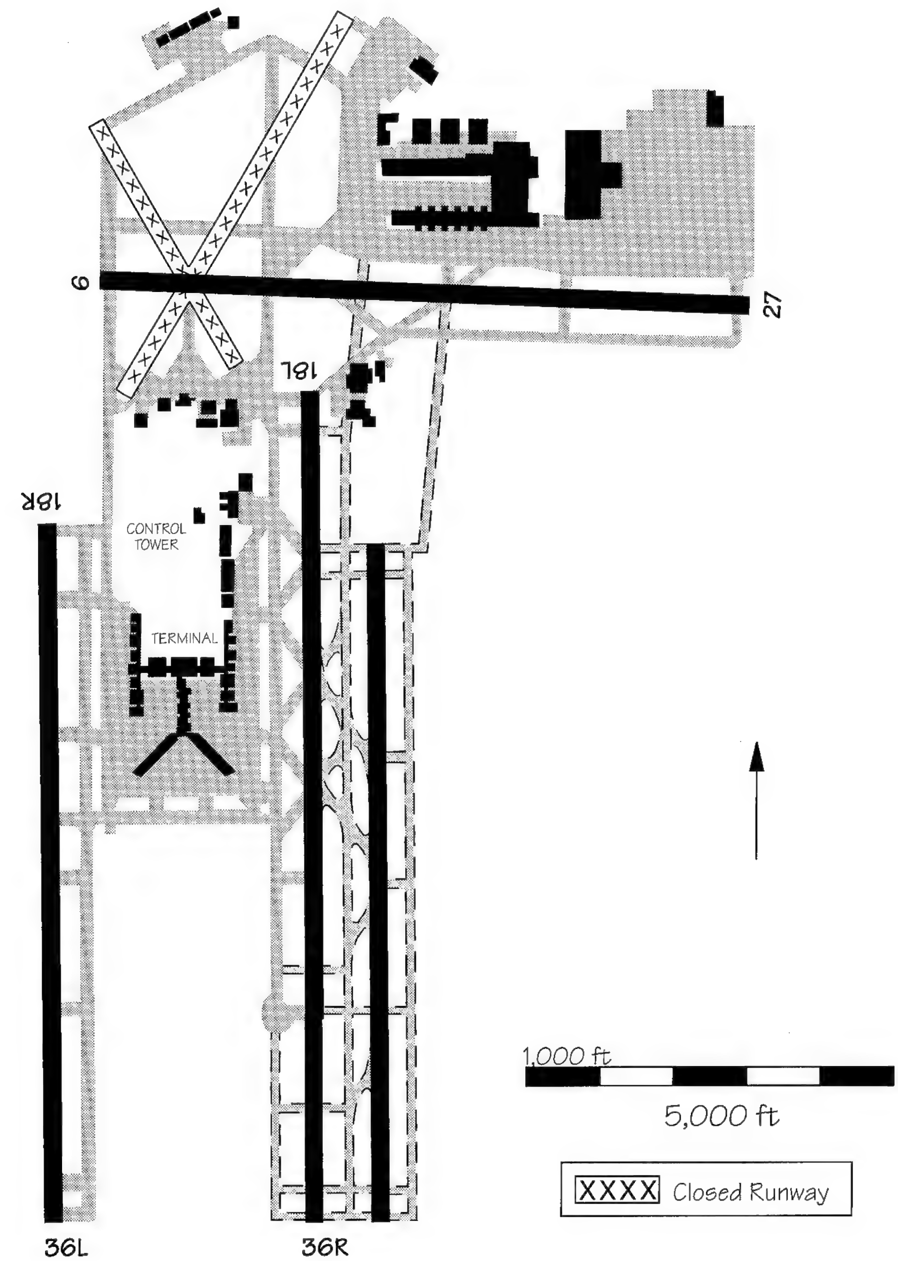
Madison/Dane County Regional Airport (MSN)

A new runway, Runway 3/21, is proposed to be built to provide additional operational capabilities to direct flights away from noise sensitive areas. This will be necessary when Runway 18/36 reaches its limit to run operations in reverse flow for noise abatement purposes during peak operating hours. Runway 3/21 would replace Runway 4/22. It is not feasible to extend 4/22 to have the same operational capabilities desired of Runway 3/21. The estimated cost of construction is $15 million. An EIS is underway.



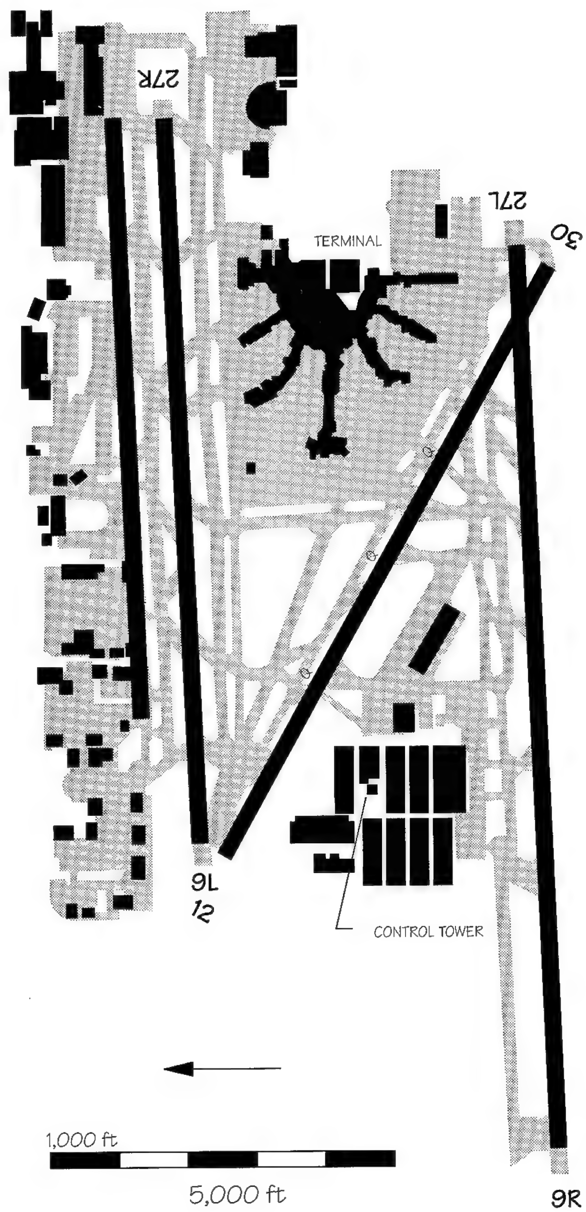
Memphis Int'l Airport (MEM)

Construction of a new north-south parallel Runway 18E/36E began in 1993. It will be located about 900 feet east of Runway 18L/36R and 4,300 feet from Runway 18R/36L, thus allowing independent parallel approaches. This will increase present hourly IFR arrival capacity by about 33 percent. The new runway should be operational in 1997. The estimated cost is $88.8 million. An extension of Runway 18L/36R is also planned. Construction is expected to start in 1997 and be completed by 1999 at a cost of $58 million.



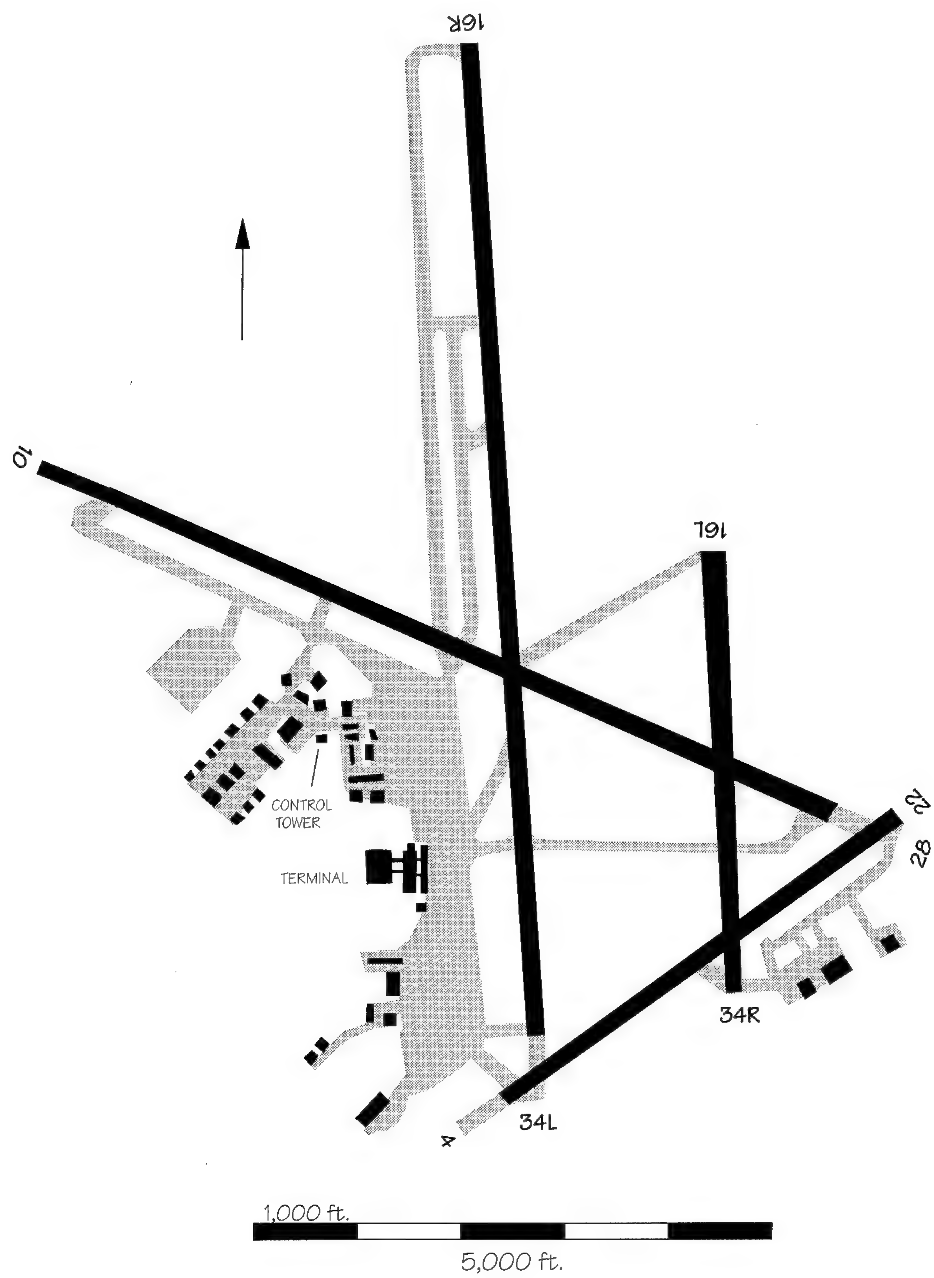
Miami Int'l Airport (MIA)

Construction of a new air carrier runway 8,600 feet long and 800 feet north of existing Runway 9L/27R is expected to start in 1997 and be completed by late 1999. The estimated cost of construction is $170 million.



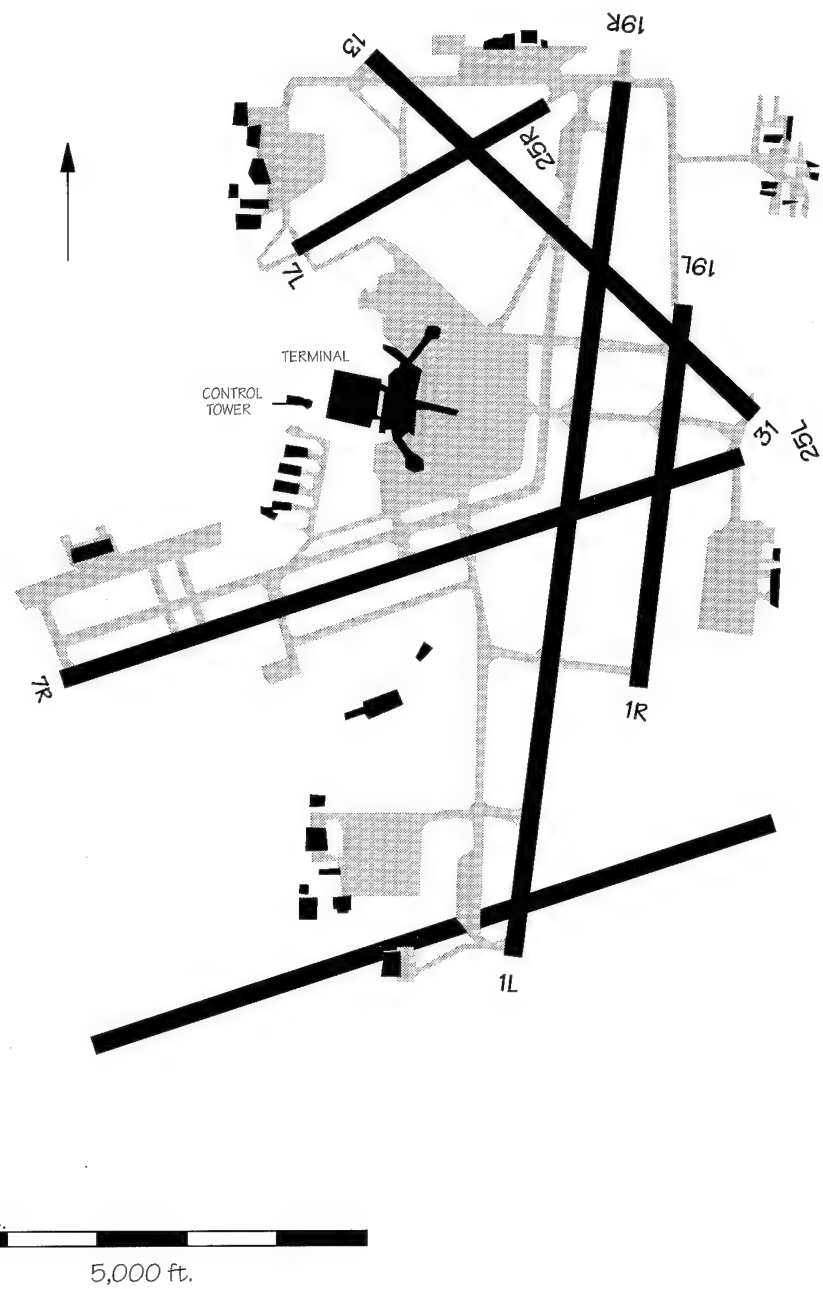
Midland Int'l Airport (MAF)

An extension to Runway 10/28 is planned, and construction is scheduled to begin in 2005.



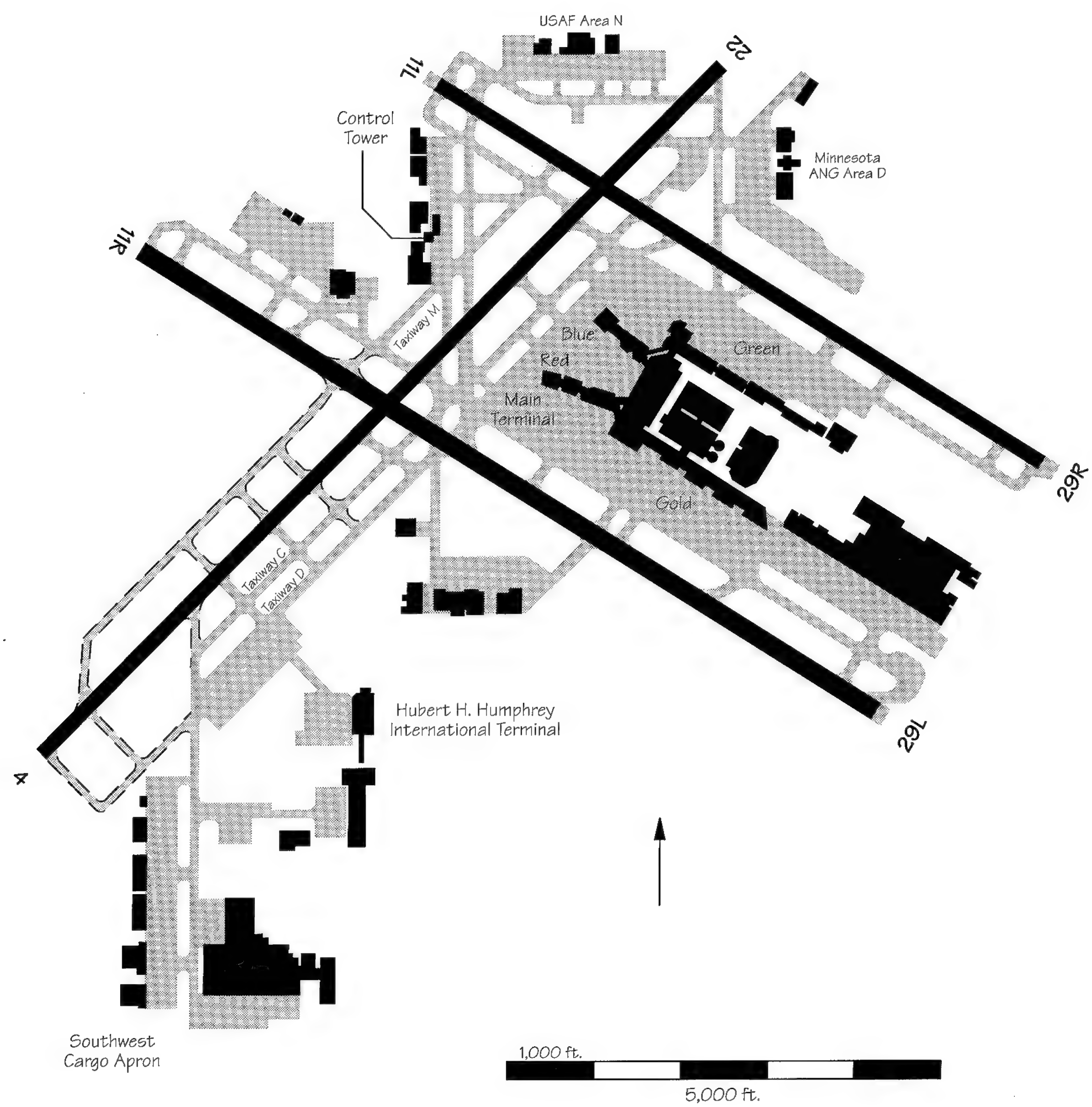
Milwaukee General Mitchell Int'l Airport (MKE)

Construction of a new parallel Runway 7R/25L 3,500 feet south of the existing runway is expected to start in 1999 and be completed in 2003. The estimated cost of construction is $150 million.



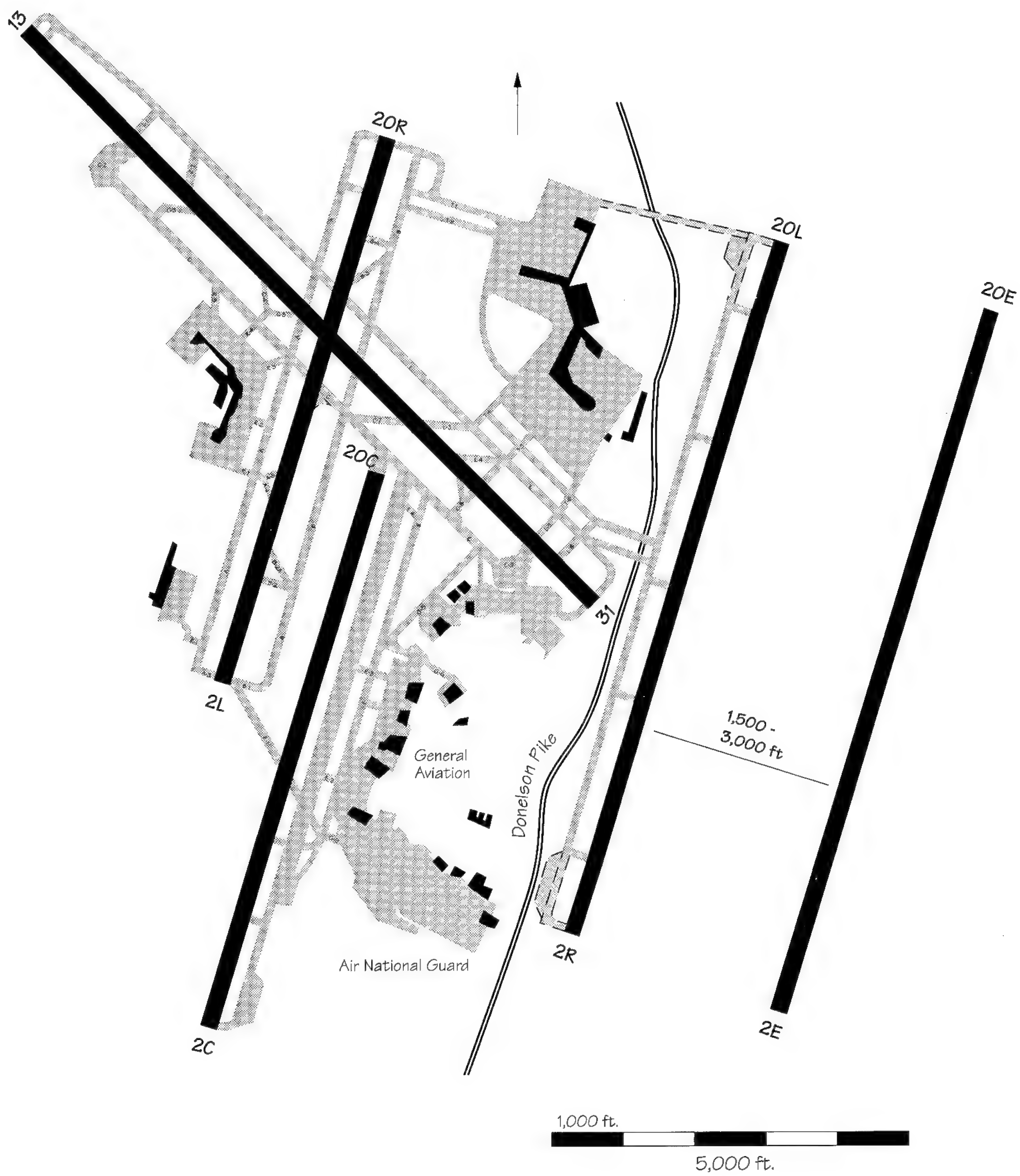
Minneapolis-St. Paul Int'l Airport (MSP)

An extension of Runway 4/22 2,750 feet to the southwest is proposed, which would bring the runway length to 11,000 feet. Construction is scheduled to begin in late 1994, and the extension should be operational in late 1995. The estimated cost of construction is $12.5 million. Associated taxiway improvements will cost an additional $14.5 million and noise mitigation for the runway extension will cost $29.4 million. Taxiway improvements are expected to be completed by late 1996.



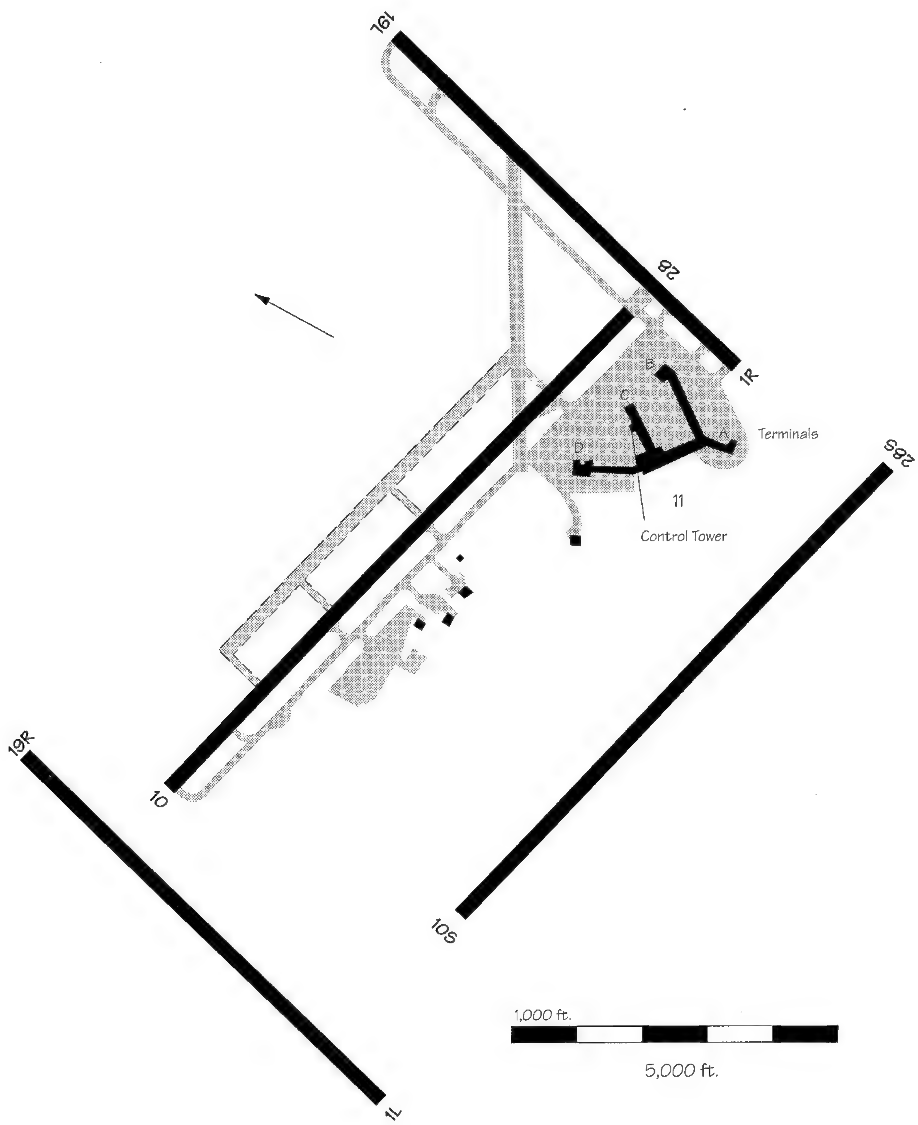
Nashville Int'l Airport (BNA)

The relocation and extension of Runway 2C/20C has been completed and is operational A new Runway 2E/20E is planned for the future between 1,500 and 3,500 feet from Runway 2R/20L. In addition, an extension to Runway 2R/20L is planned. It is expected to be completed by 2000, at an estimated cost of $38.6 million.



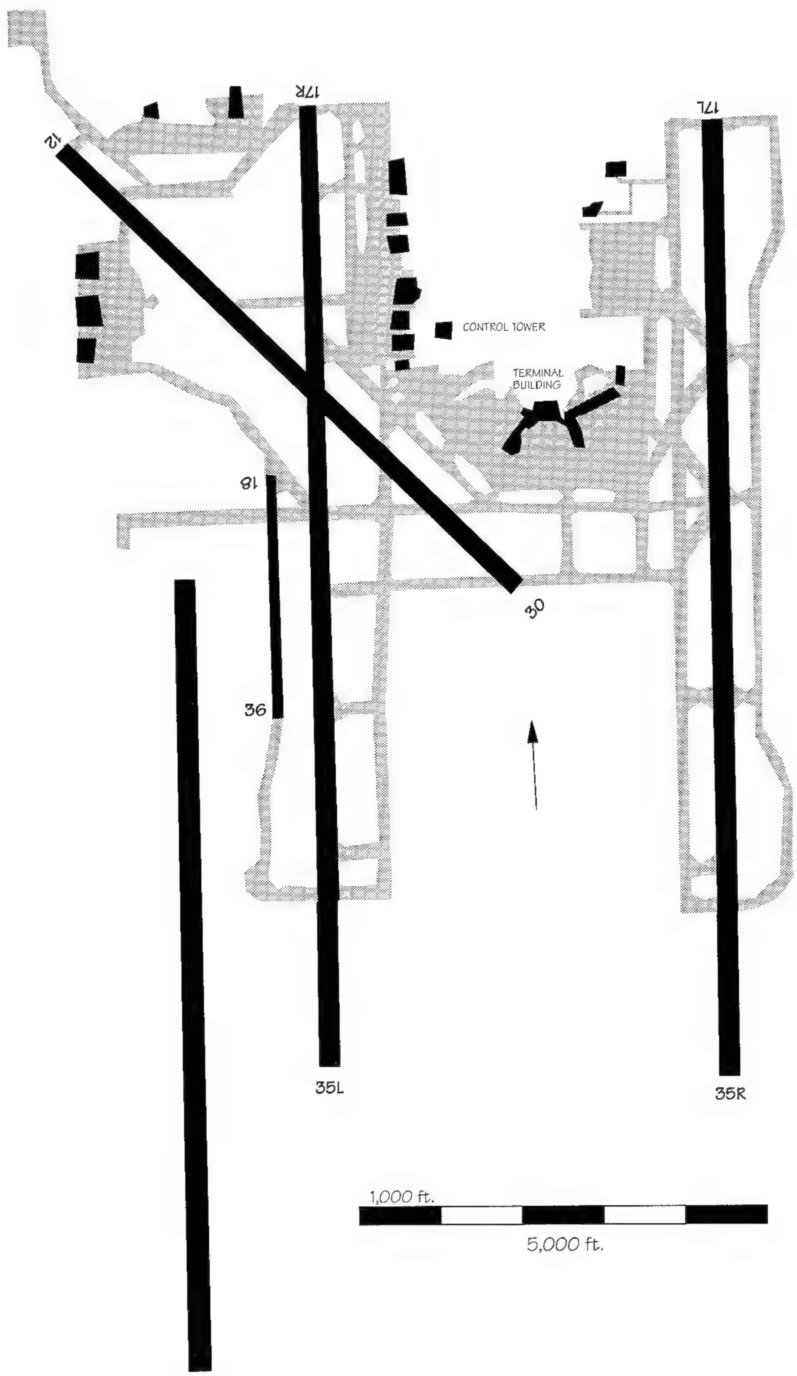
New Orleans Int'l Airport (MSY)

A new north-south runway, Runway 1L/19R, is planned. This new runway will be parallel to the existing Runway 1/19 and will be located west of the threshold of Runway 10, approximately 11,000 feet away from Runway 1/19. This will allow independent parallel operations, doubling IFR hourly arrival capacity. Pending environmental approvals, construction could begin as early as January 1996 and be completed in 2000, at an approximate cost of $340 million. As an alternative to this north-south runway, the airport is considering the construction of an east/west parallel runway, Runway 10S/28S, 4,300 feet to the south of existing Runway 10/28, off of present airport property. The estimated cost of construction is $460 million. The airport is also planning to construct a north parallel east/west taxiway approximately 800 feet north of and parallel to the existing Runway 10/28, which could later be converted into a 6,000-foot commuter and general aviation runway. The site preparation phase of the taxiway construction has already begun. The estimated cost of construction is $25.5 million, and the expected operational date is 1995.



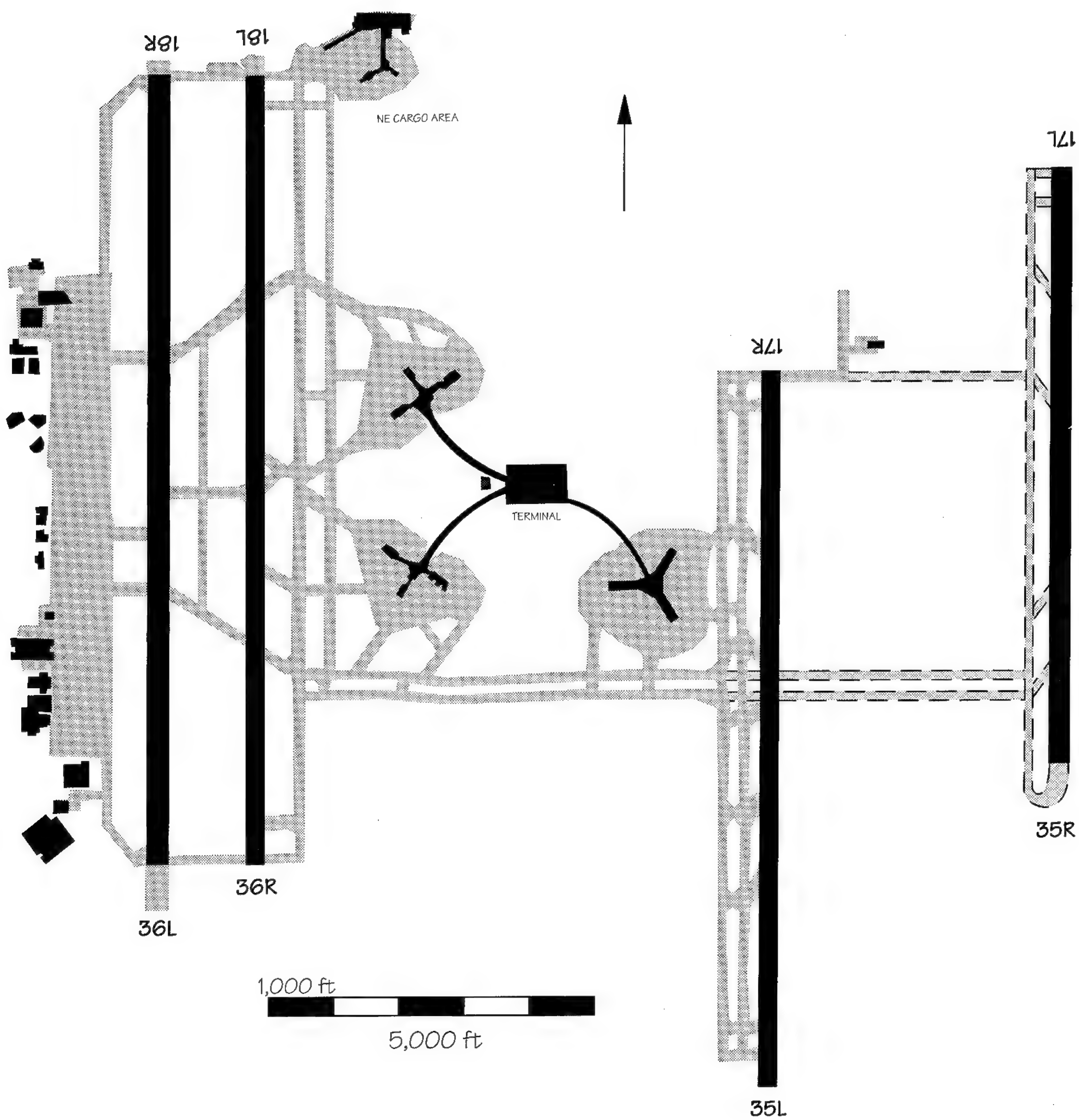
Oklahoma City Will Rogers World Airport (OKC)

Construction of a new west parallel runway 1,600 feet west of of Runway 17R/35L is planned to be operational by 2004. Estimated cost of construction is $13 million. Extensions to both north/south runways, Runways 17L/35R and 17R/35L are also planned. The estimated costs of extending 17L/35R is $8 million. Construction of the extension to Runway 17R/35L is expected to start in 2001 and be operational by 2014, at an estimated cost of $8 million.



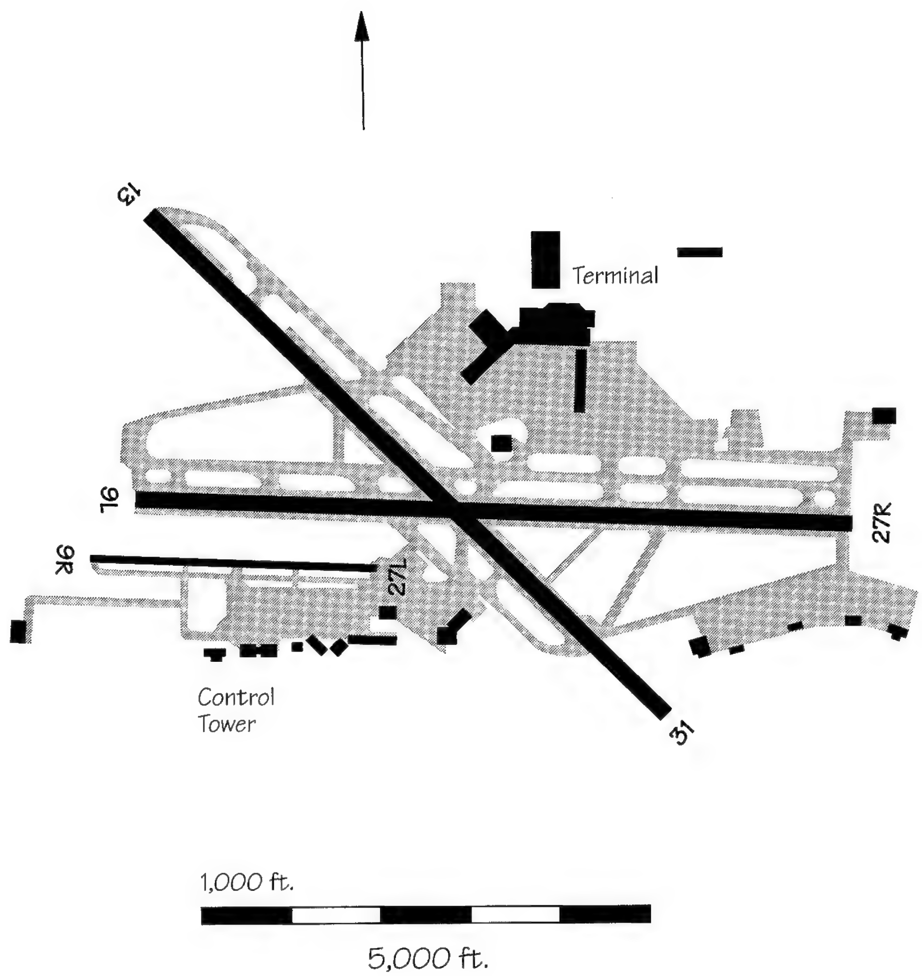
Orlando Int'l Airport (MCO)

Construction of a fourth north-south runway, Runway 17L/35R, began October 10, 1990. The runway is expected to be operational in 2000. It will be located 4,300 feet east of Runway 17R/35L. This may permit triple independent IFR operations. The estimated cost of construction of this runway is $115 million.



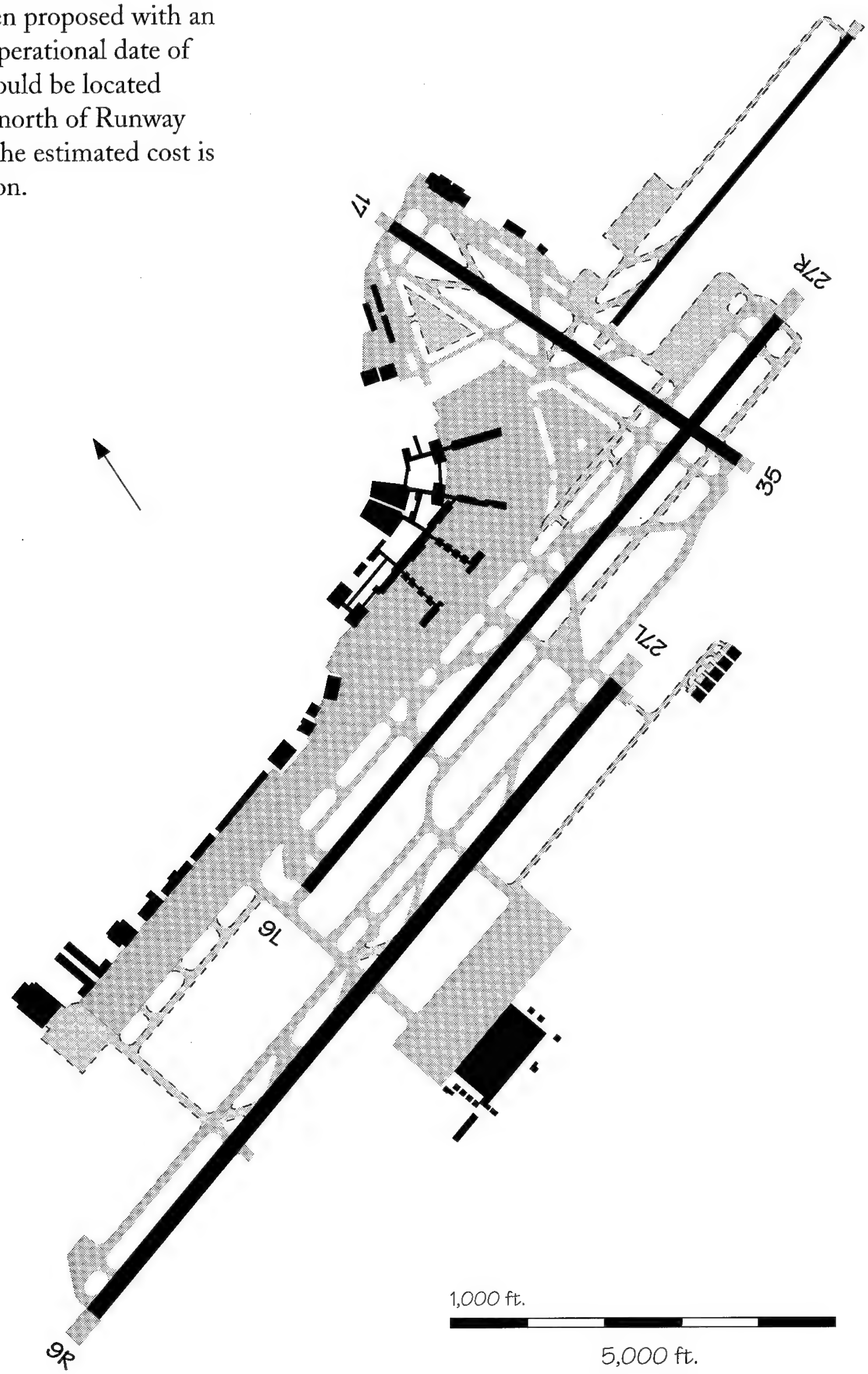
Palm Beach Int'l Airport (PBI)

Runway 9L/27R will be extended 1,200 feet to the west and 811 feet to the east, for a total length of 10,000 feet. Construction is not expected to start until 1995 or later. The total estimated project cost is $4.8 million. In addition, an extension of Runway 13/31 is planned to be completed in 1999 at a cost of $1 million. A 700 foot extension of Runway 9R/27L is also being considered for completion in 1999 or later at a cost of $0.5 million.



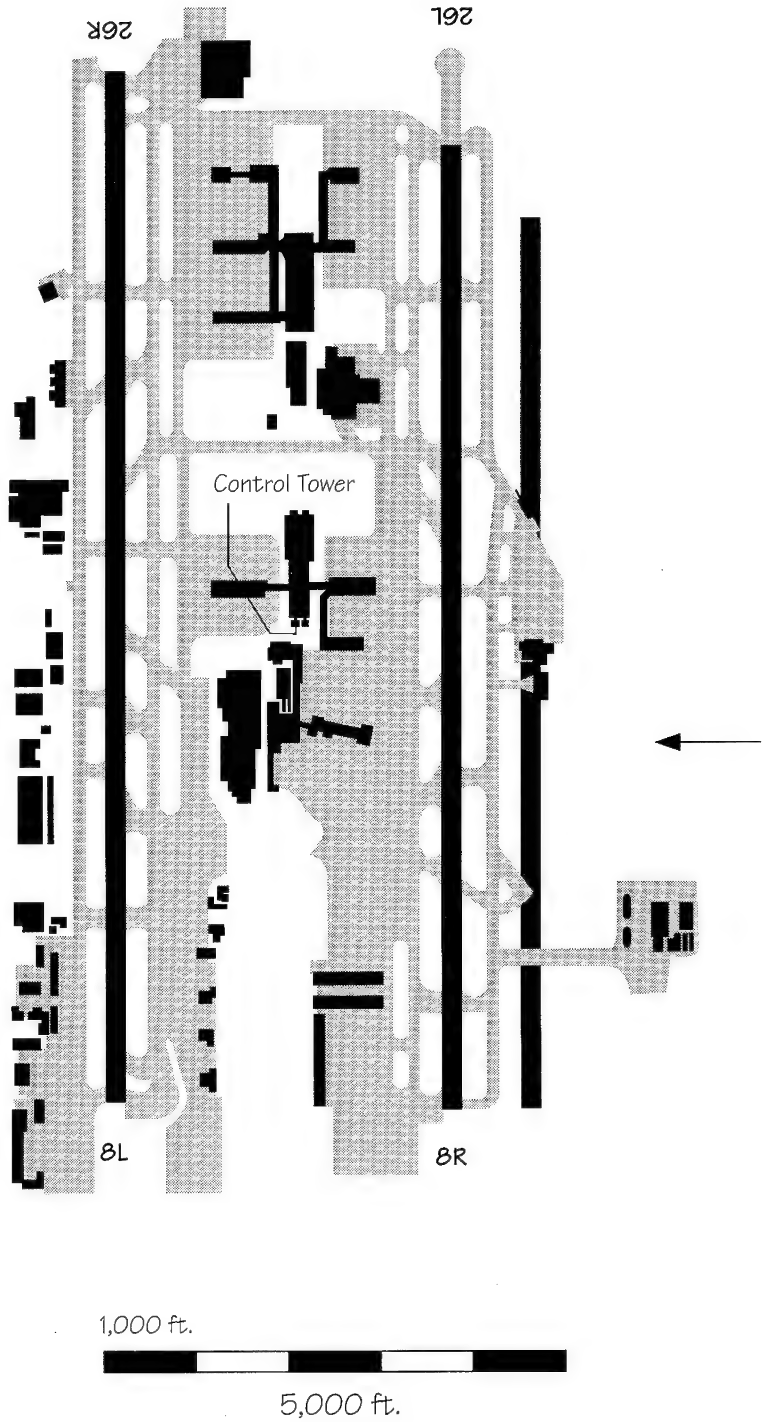
Philadelphia Int'l Airport (PHL)

A new 5,000-foot parallel commuter runway, Runway 8/26, has been proposed with an expected operational date of 1997. It would be located 3,000 feet north of Runway 9R/27L. The estimated cost is $215 million.



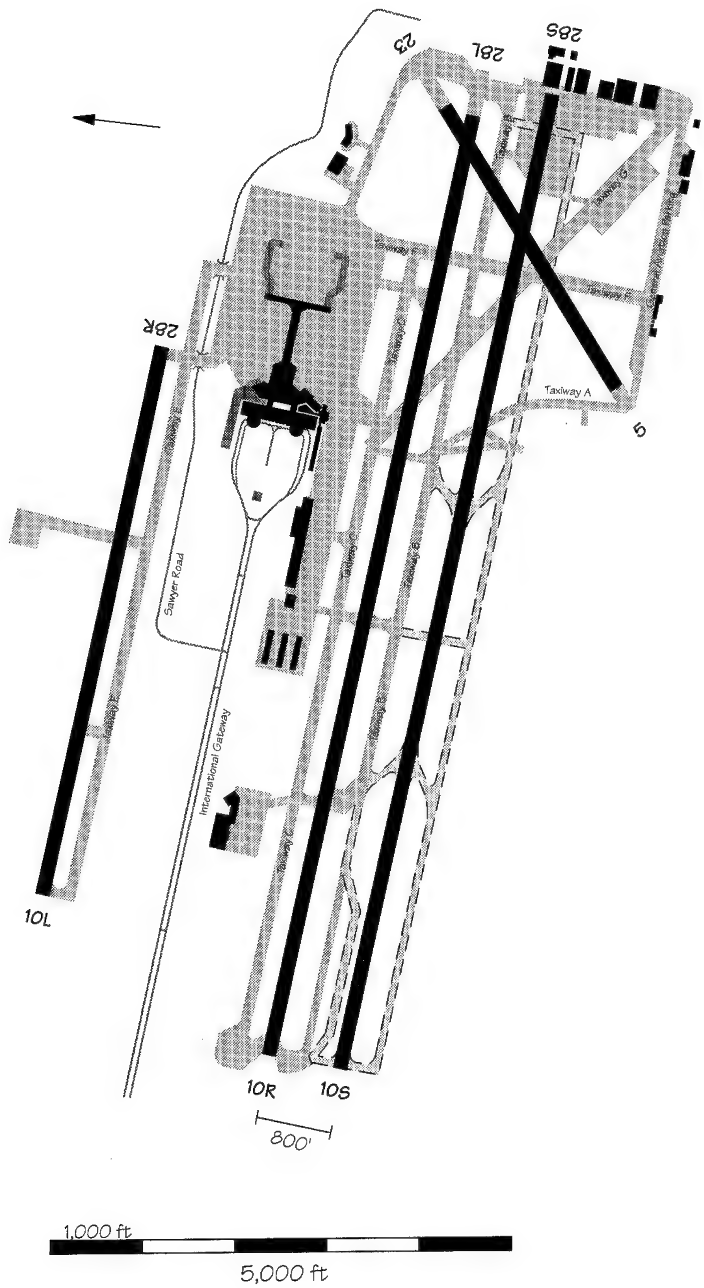
Phoenix Sky Harbor Int'l Airport (PHX)

A new 9,500-foot third parallel runway, Runway 7/25, is proposed 800 feet south of Runway 8R/26L. The estimated cost of construction is $88 million. The estimated operational date for the first 7,800 feet of Runway 7/25 is 1996; the remaining 1,700 feet of the runway is not scheduled at this time. In addition, an extension of Runway 8L/26R is under consideration. The estimated cost of construction is $7.0.



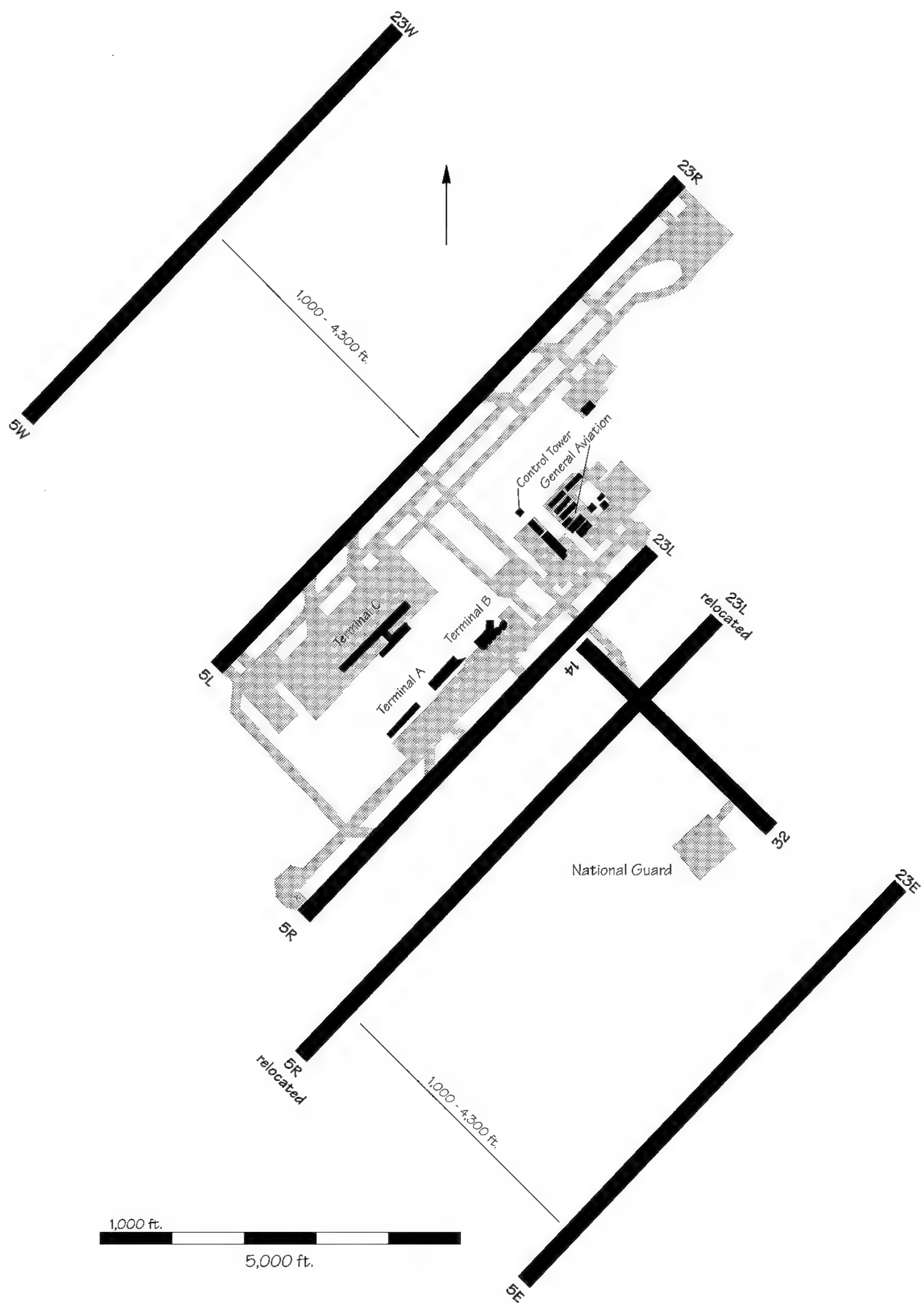
Port Columbus Int'l Airport (CMH)

The Airport Layout Plan has been coordinated to show a third parallel Runway 10S/28S constructed 800 feet south of the existing Runway 10R/28L. This runway will be 10,250 feet long and 150 feet wide, with two high speed exits, a 90 degree exit at the center, and a 90 degree bypass taxiway at each end. This would provide a 3,650 foot separation between the proposed Runway 10S/28S and the existing Runway 10L/28R. With the installation of the Precision Runway Monitor (PRM), the existing Runway 10L/28R and the proposed Runway 10S/28S could be used for arrival air traffic. Runway 10R/28L would be used as the departure runway.



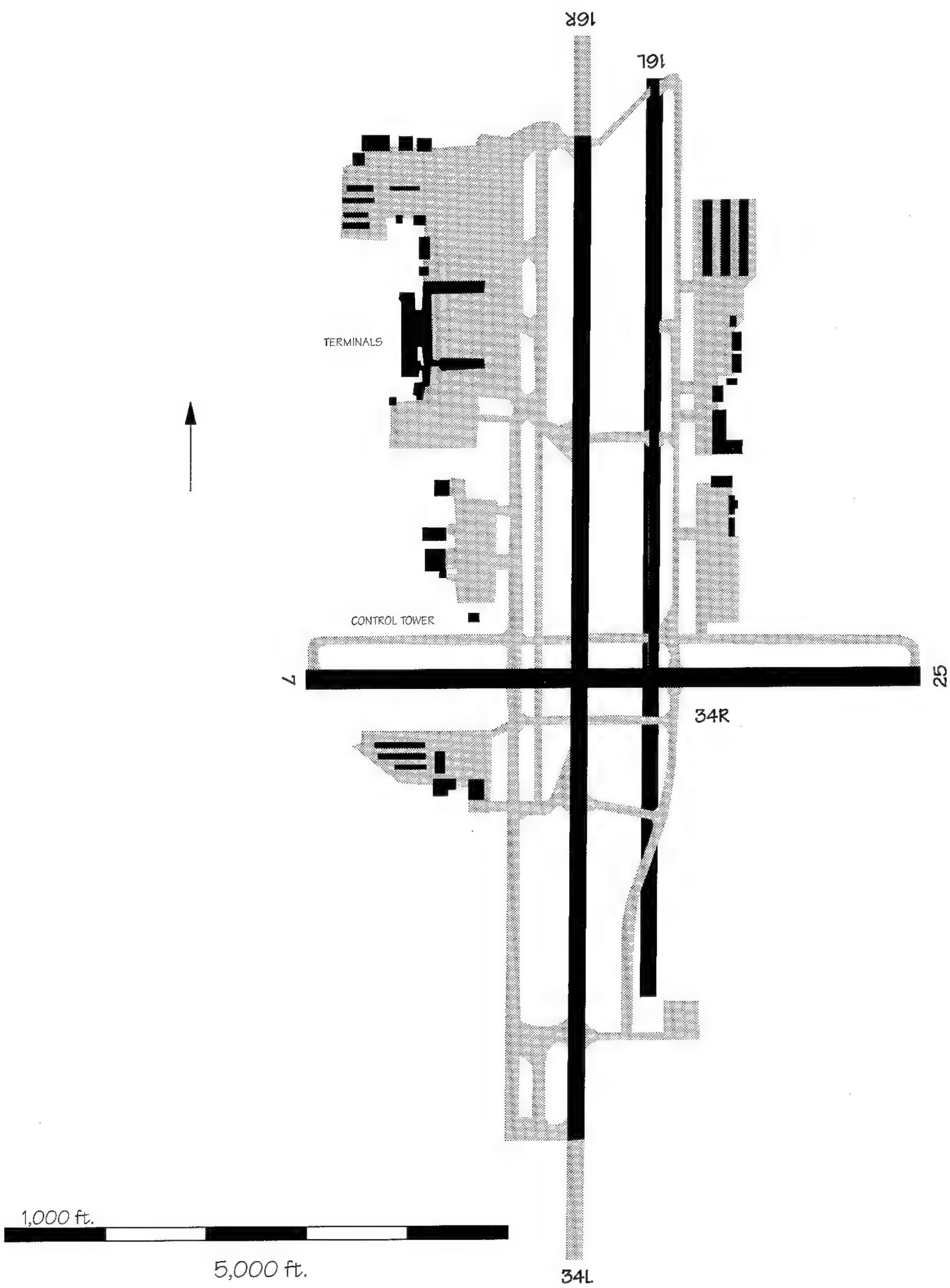
Raleigh-Durham Int'l Airport (RDU)

The relocation of Runway 5R/23L and its associated taxiways is being considered. The new runway will be parallel to and approximately 450-1,200 feet southeast of existing Runway 5R/23L. It will be a 9,000-foot long air carrier runway. Two other runways are proposed for eventual construction. Runway 5W/23W would be located 1,000 to 4,300 feet to the northwest of Runway 5L/23R, and Runway 5E/23E would be located 1,000 to 4,300 feet to the southeast of the relocated Runway 5R/23L. The actual sequence of these developments will be decided after a study by a long-range planning committee.



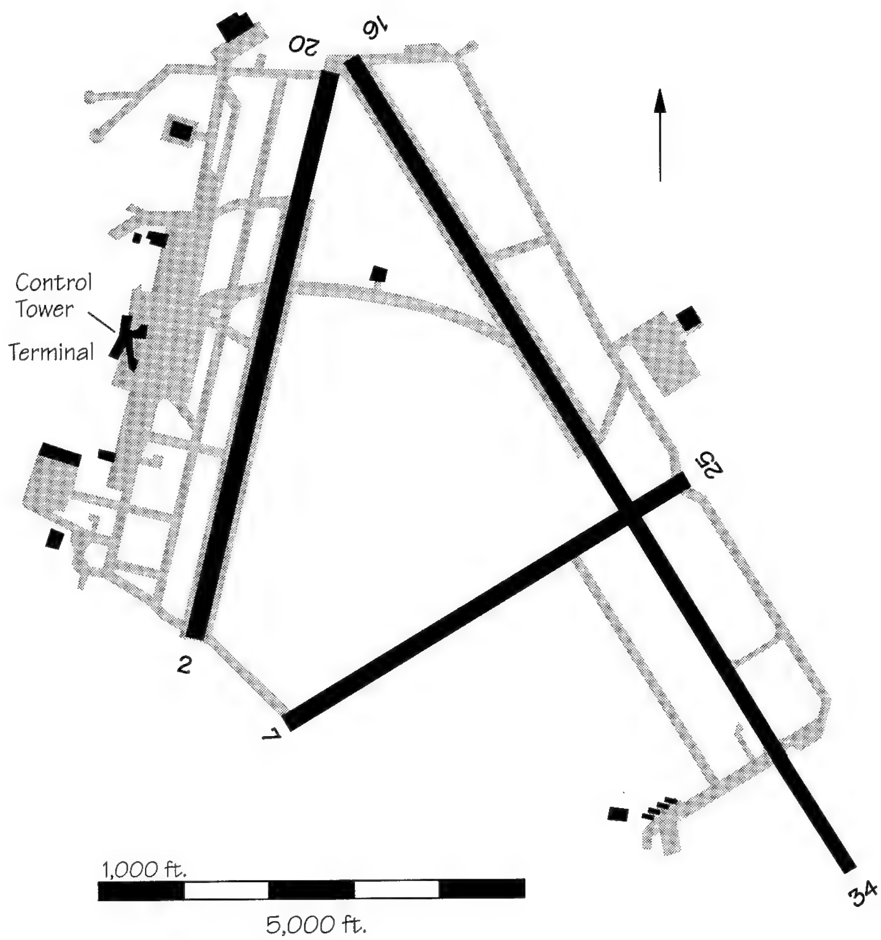
Reno Cannon Int'l Airport (RNO)

Construction began April 23, 1993 to extend and widen Runway 16L/34R. The estimated operational date is the summer of 1994, and the estimated cost of construction is $22 million.



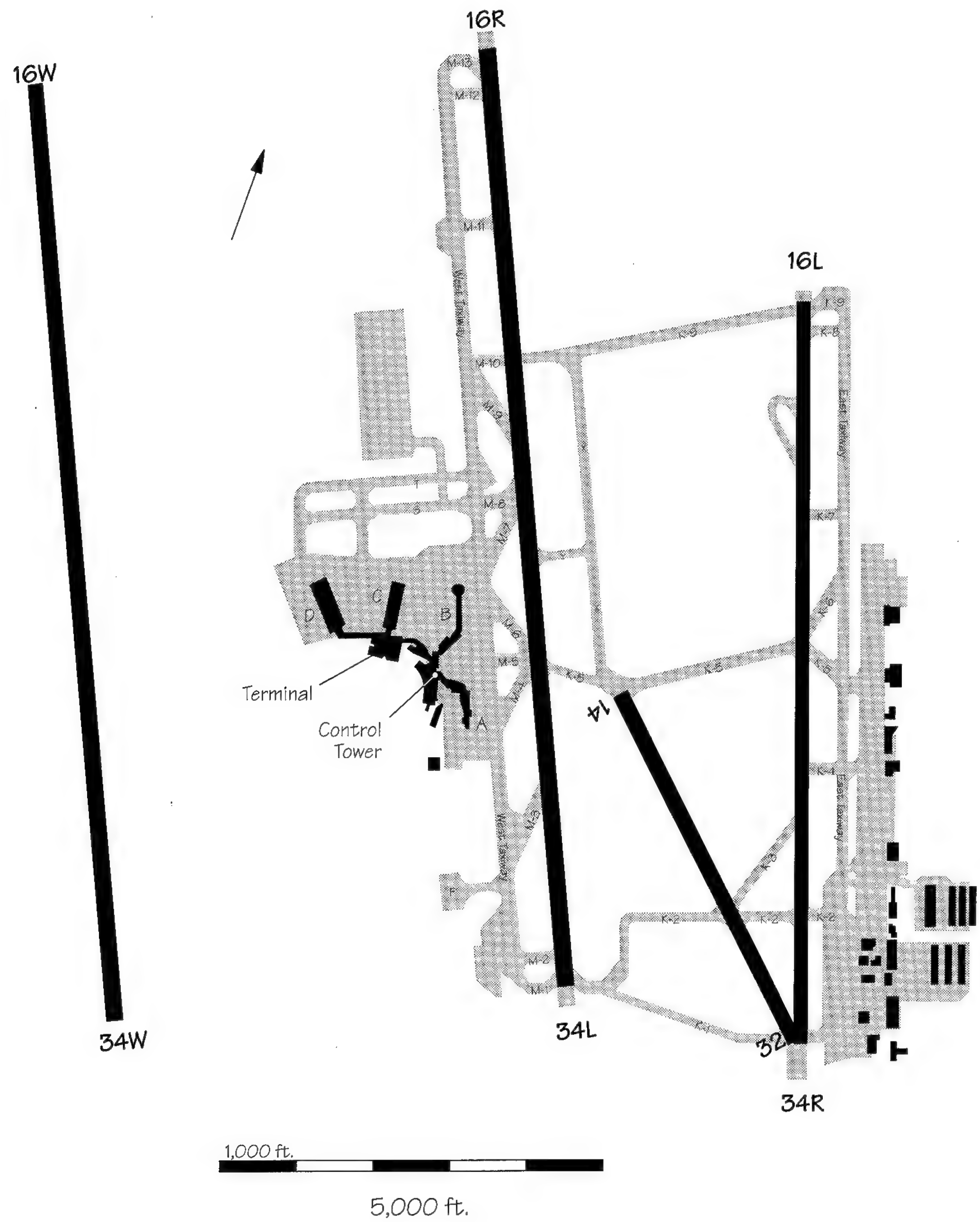
Richmond Int'l Airport (RIC)

An extension of Runway 16/34 is planned for an operational date of January 1997. The estimated cost of construction is $12 million.



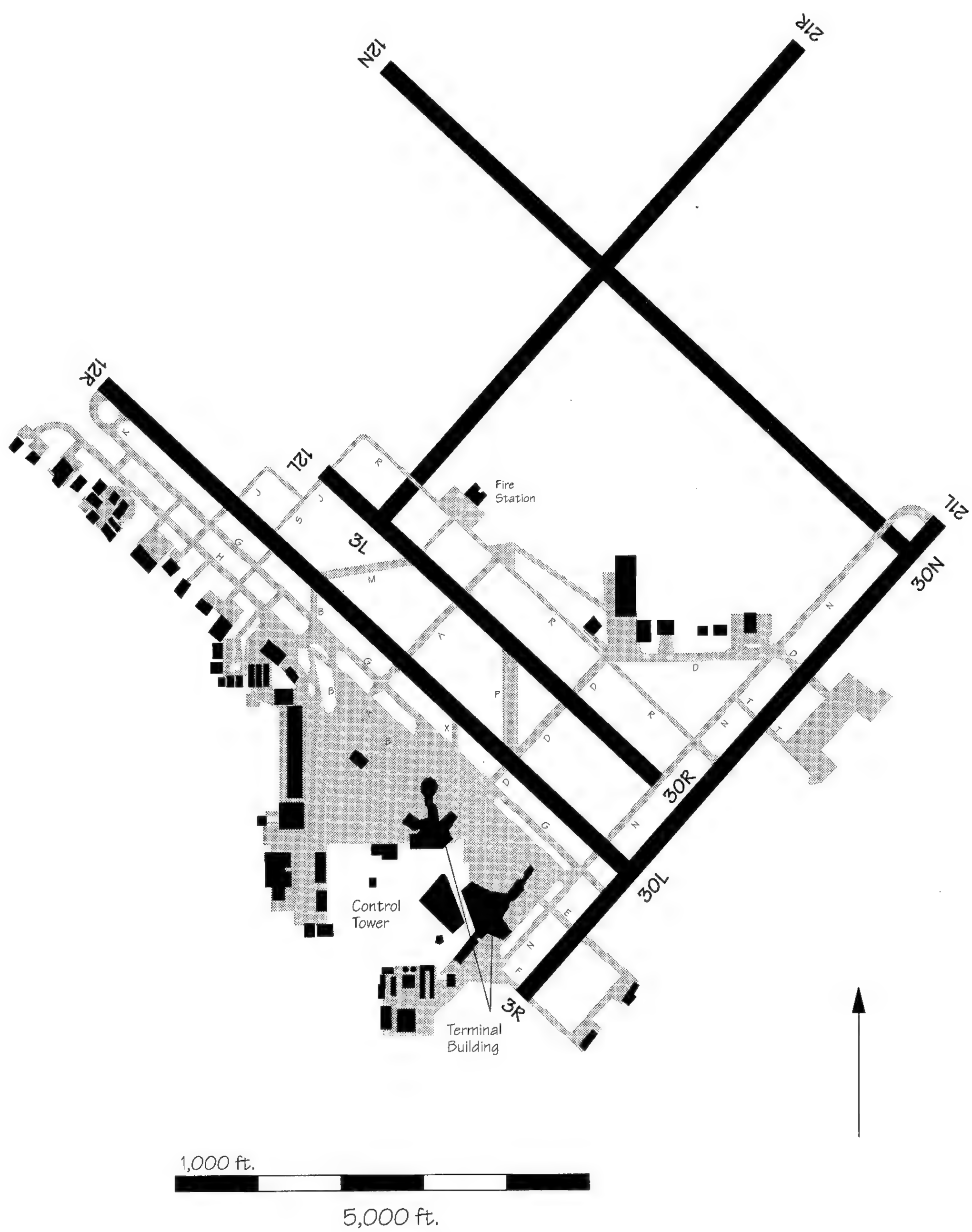
Salt Lake City Int'l Airport (SLC)

Construction of a new 12,000 foot runway parallel to and 6,300 feet west of existing Runway 16R/34L began May 17, 1993. The estimated cost of construction is $120 million. This new runway will permit independent parallel approaches.



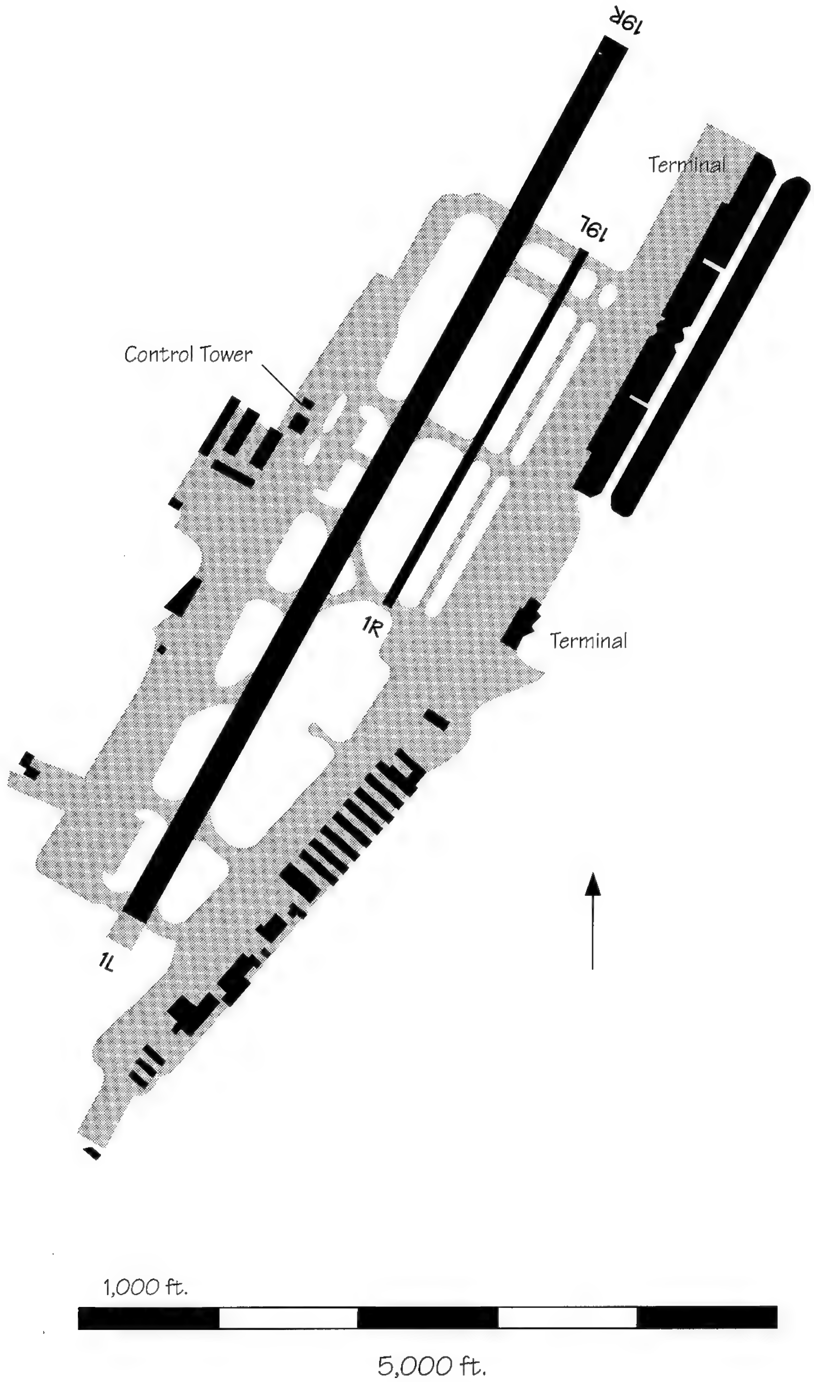
San Antonio Int'l Airport (SAT)

Construction of a new north/south parallel runway is being considered. With a tentative operational date of 2005.



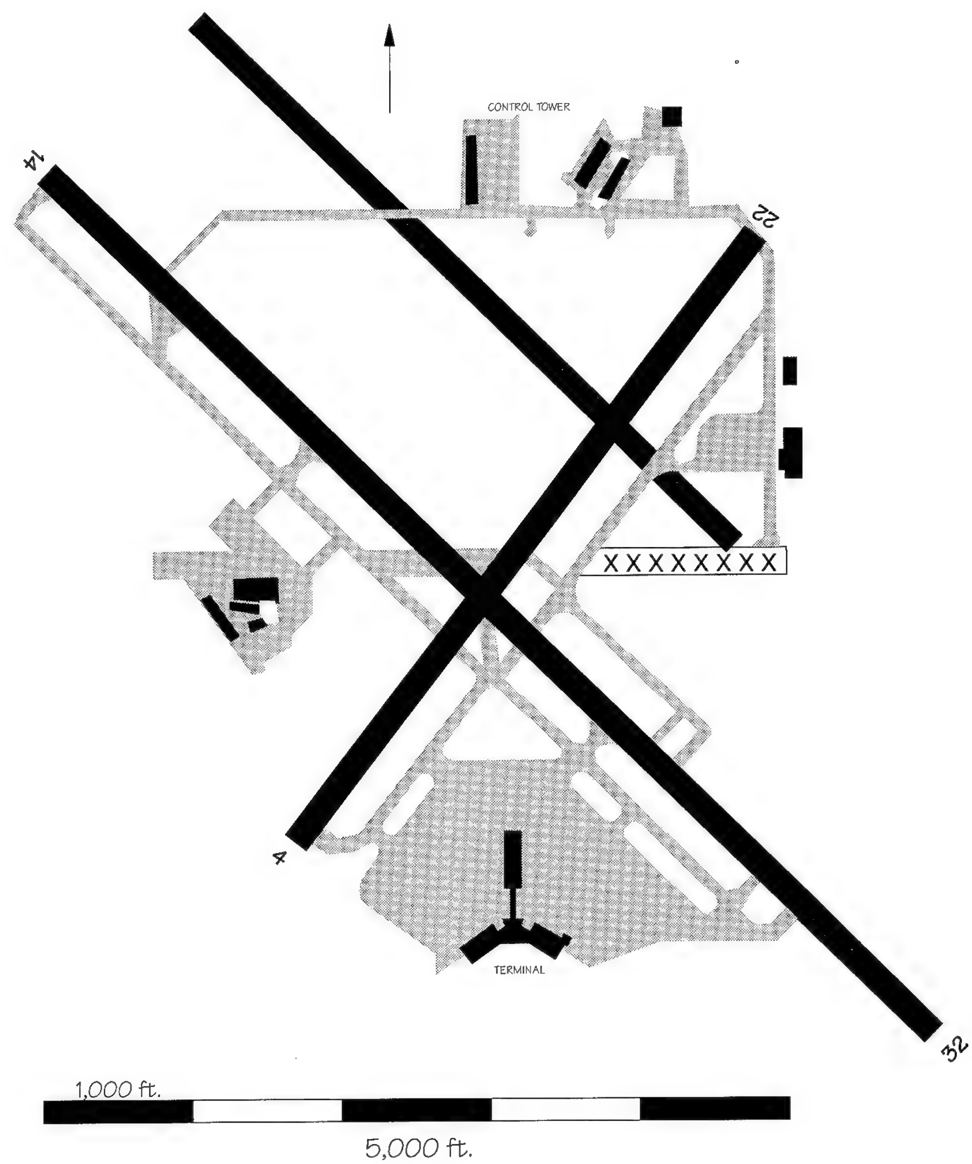
Santa Ana John Wayne Airport - Orange County (SNA)

An extension of Runway 1L/19R is under consideration.



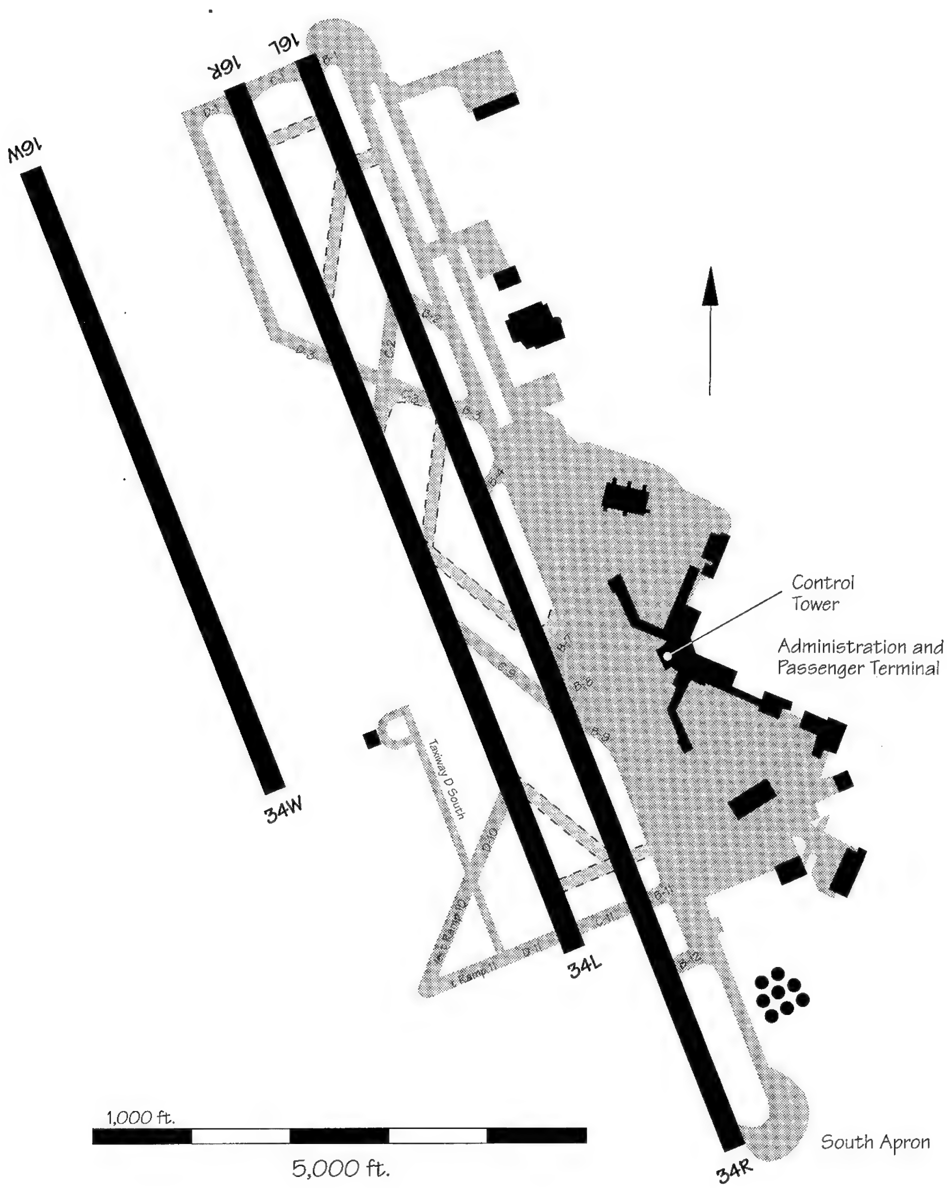
Sarasota Bradenton Airport (SRQ)

A new parallel Runway 14L/32R 1,230 feet northwest of Runway 14/32 is being planned at an estimated cost of $9 million. It is expected to be operational by 1998. In addition, an extension of the existing Runway 14/32 is planned at a cost of $4.3 million. It is expected to be complete in 1996.



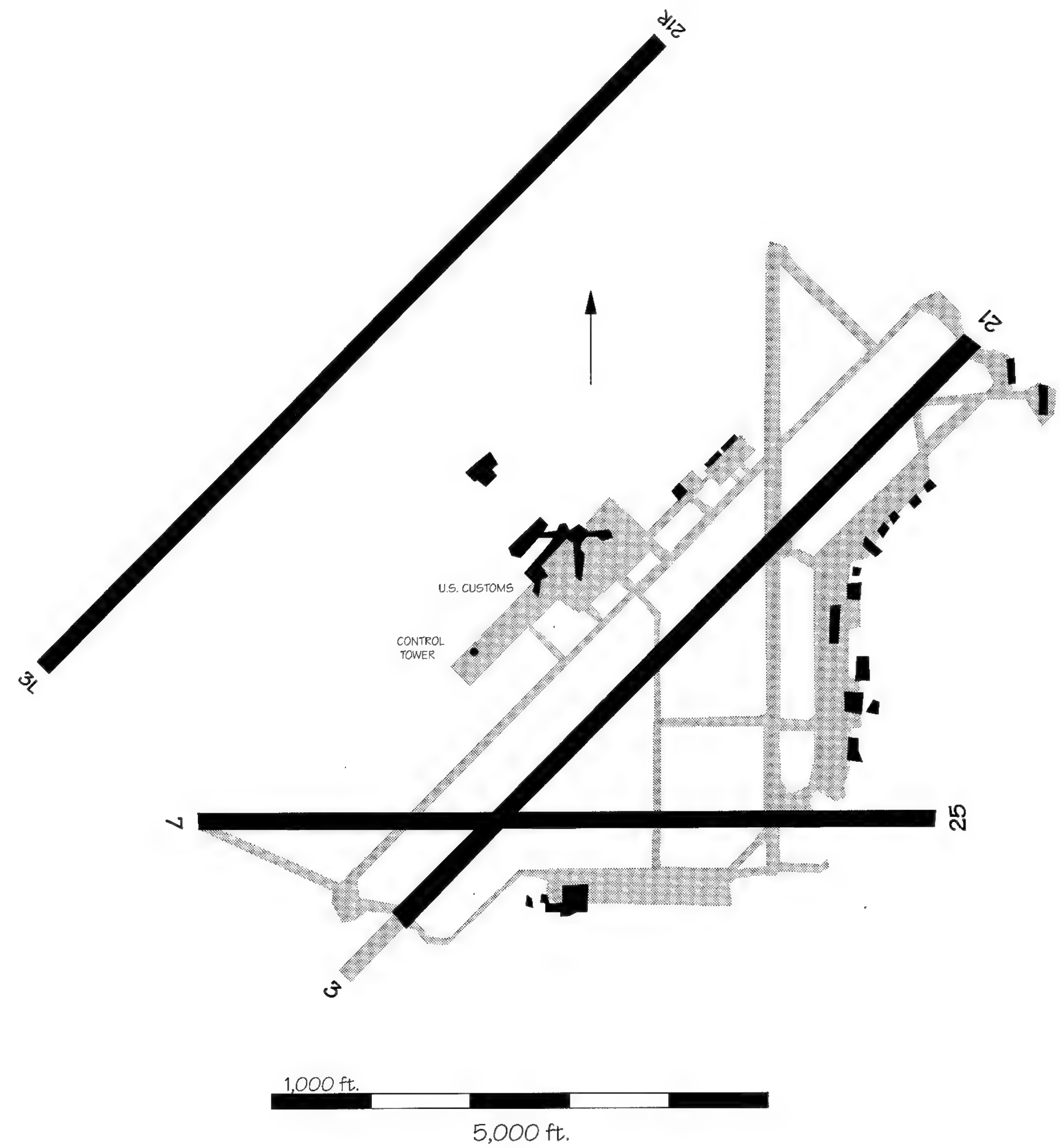
Seattle-Tacoma Int'l Airport (SEA)

Potential airport improvements include a new parallel runway, Runway 16W/34W, which will be located 2,500 feet from Runway 16L/34R. A decision on construction will be made in 1996, and the estimated cost of construction is $400 million.



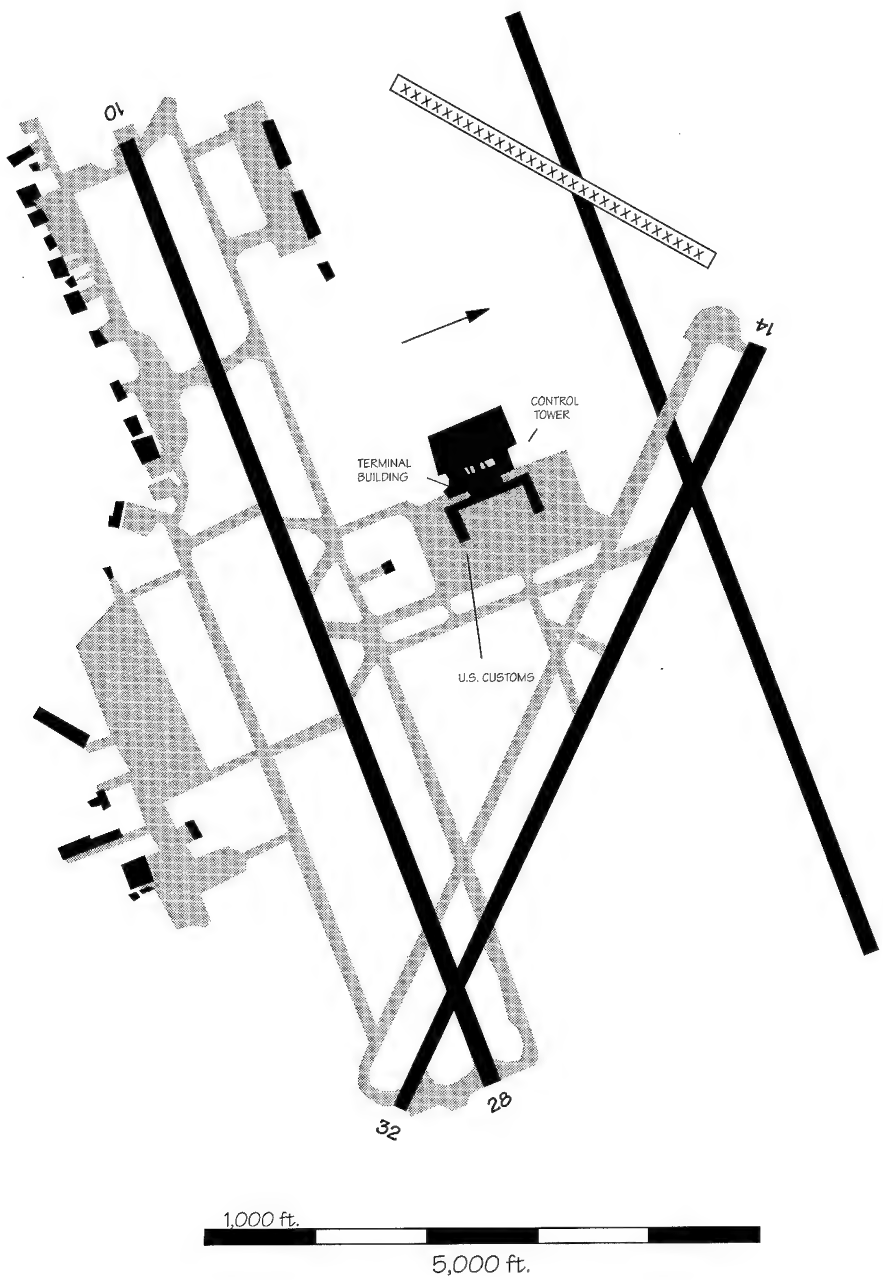
Spokane Int'l Airport (GEG)

Future projects include the construction of a new parallel Runway 3L/21R. The new runway will be 8,800 feet long by 150 feet wide and will be separated from Runway 3R/21L by 4,400 feet. This would enable independent parallel operations, doubling hourly IFR arrival capacity. The estimated cost of construction of the new runway is approximately $11 million. Construction is expected to start in 1999 and should be completed in 2001.



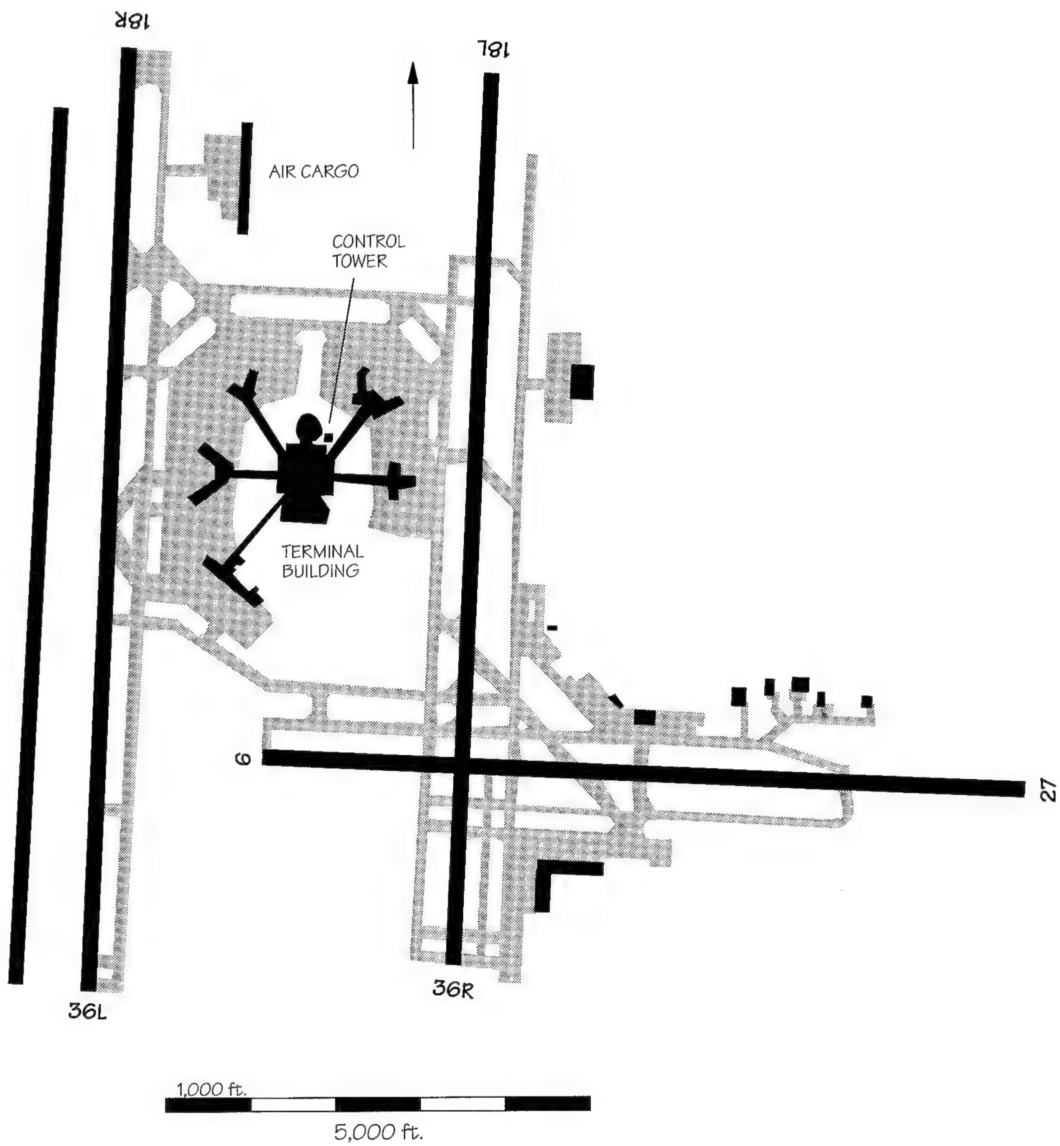
Syracuse Hancock Int'l Airport (SYR)

A new parallel Runway 10L/28R, 9,000 feet long and separated from the existing Runway 10/28 by 3,400 feet is being considered. It would provide independent parallel IFR operations, doubling hourly IFR arrival capacity. The expected operational date is 2000. The cost of construction is estimated to be $46 million for the first phase of the new runway, which would be 7,500 feet long, including a parallel taxiway and connections to the ramp. The final length of the runway will be 9,000 feet.



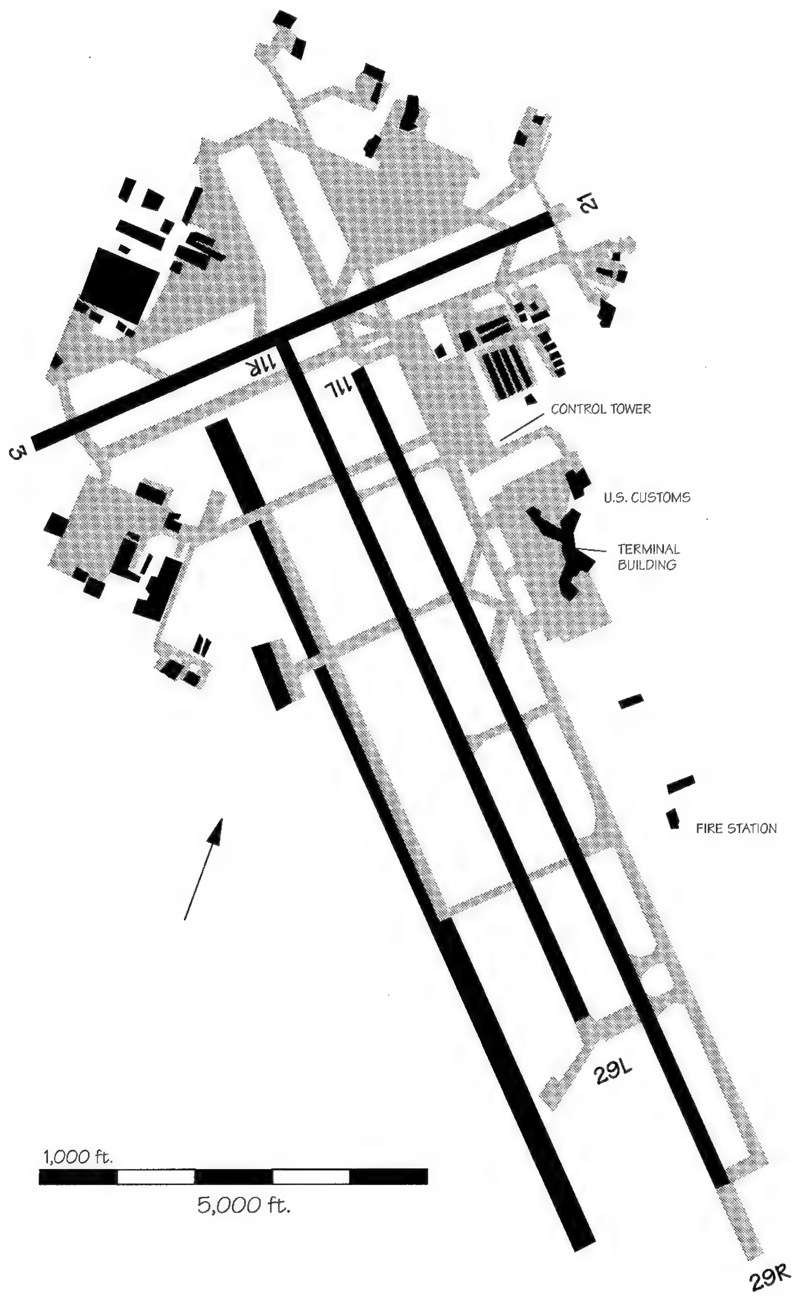
Tampa Int'l Airport (TPA)

A third parallel Runway 18R/36L 9,650 feet long and 700 feet west of Runway 18L/36R is being considered. Construction is expected to be completed by 2000, and the estimated cost of construction is $55 million. An extension of Runway 18L is also being considered for the timeframe beyond 2005, and an extension of Runway 27, for the timeframe beyond 2010.



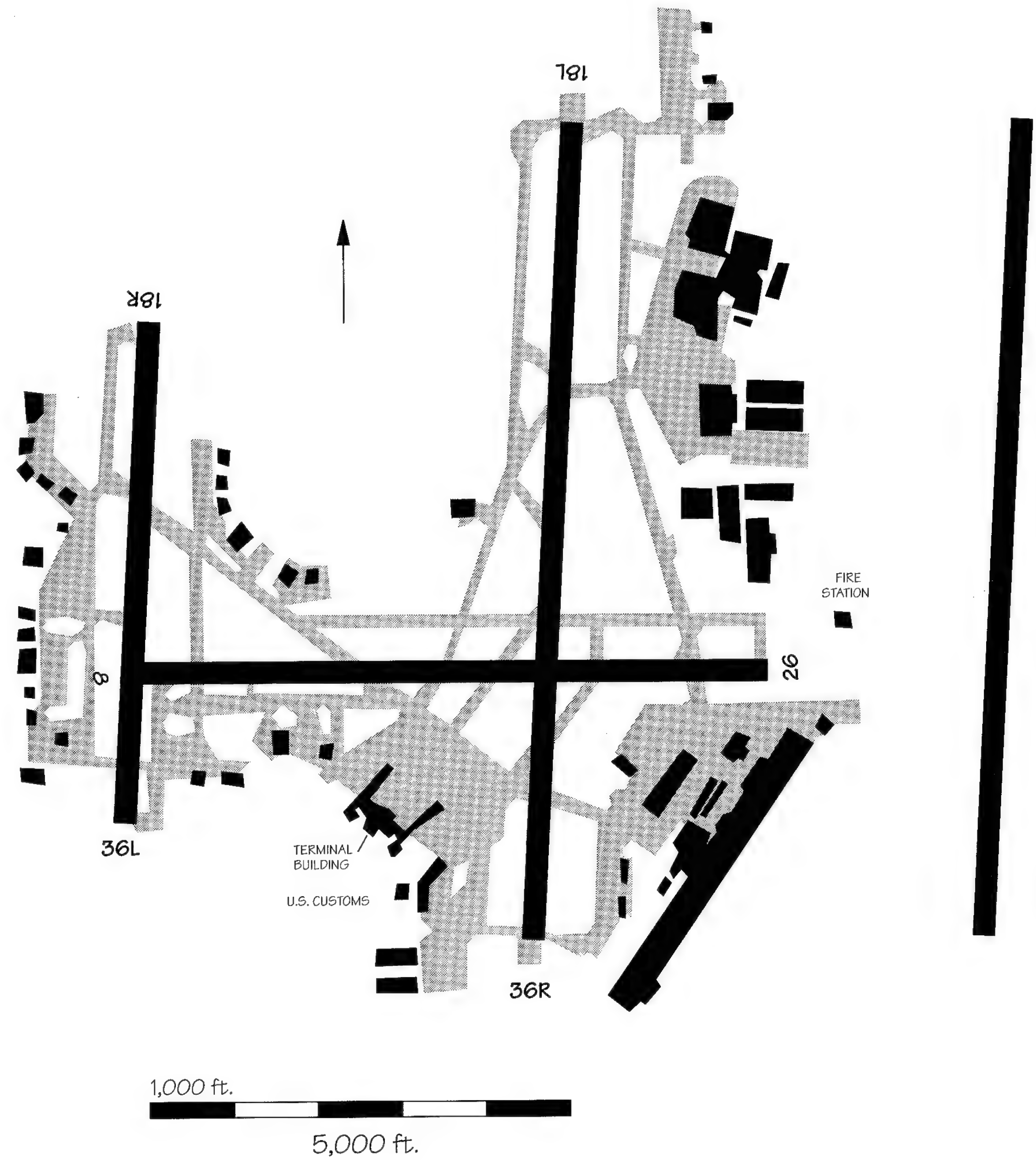
Tucson Int'l Airport (TUS)

An additional parallel air carrier runway, Runway 11R/29L, has been proposed. Upon completion of the new runway, the current Runway 11R/29L, a general aviation runway, will revert to its original taxiway status. It is not anticipated that the sponsor will proceed before 1998. Current plans call for construction to start in 2003 to be operational in 2005. The cost of construction is estimated to be $30 million.



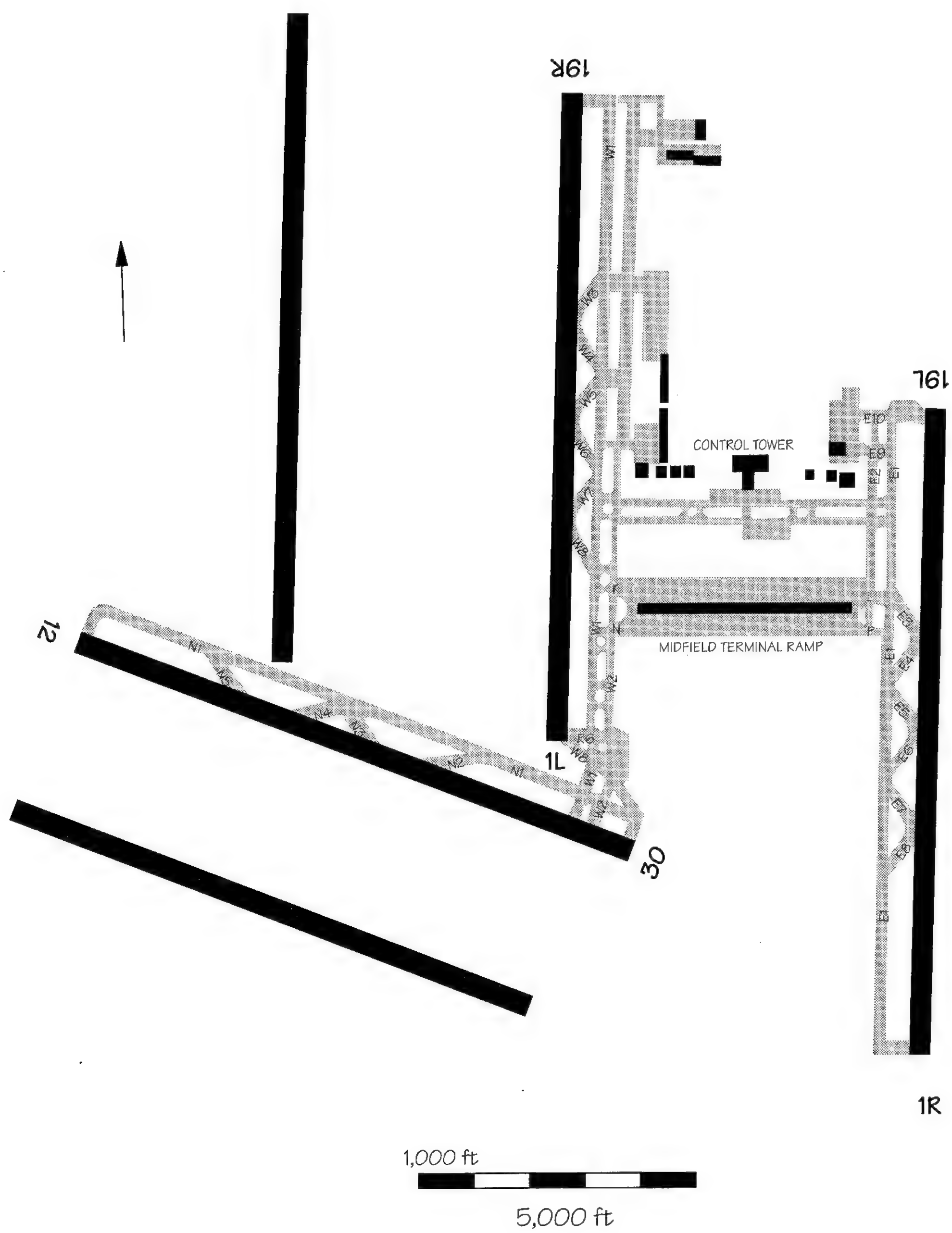
Tulsa Int'l Airport (TUL)

A new parallel runway, Runway 18L/36R, is being considered to be located 5,200 feet east of the present 18L/36R and will be 9,600 feet long. The cost of the new runway is estimated to be $115 million. The new runway could permit IFR triple independent approaches, if approved, to Runways 18L, 18C, and 18R.



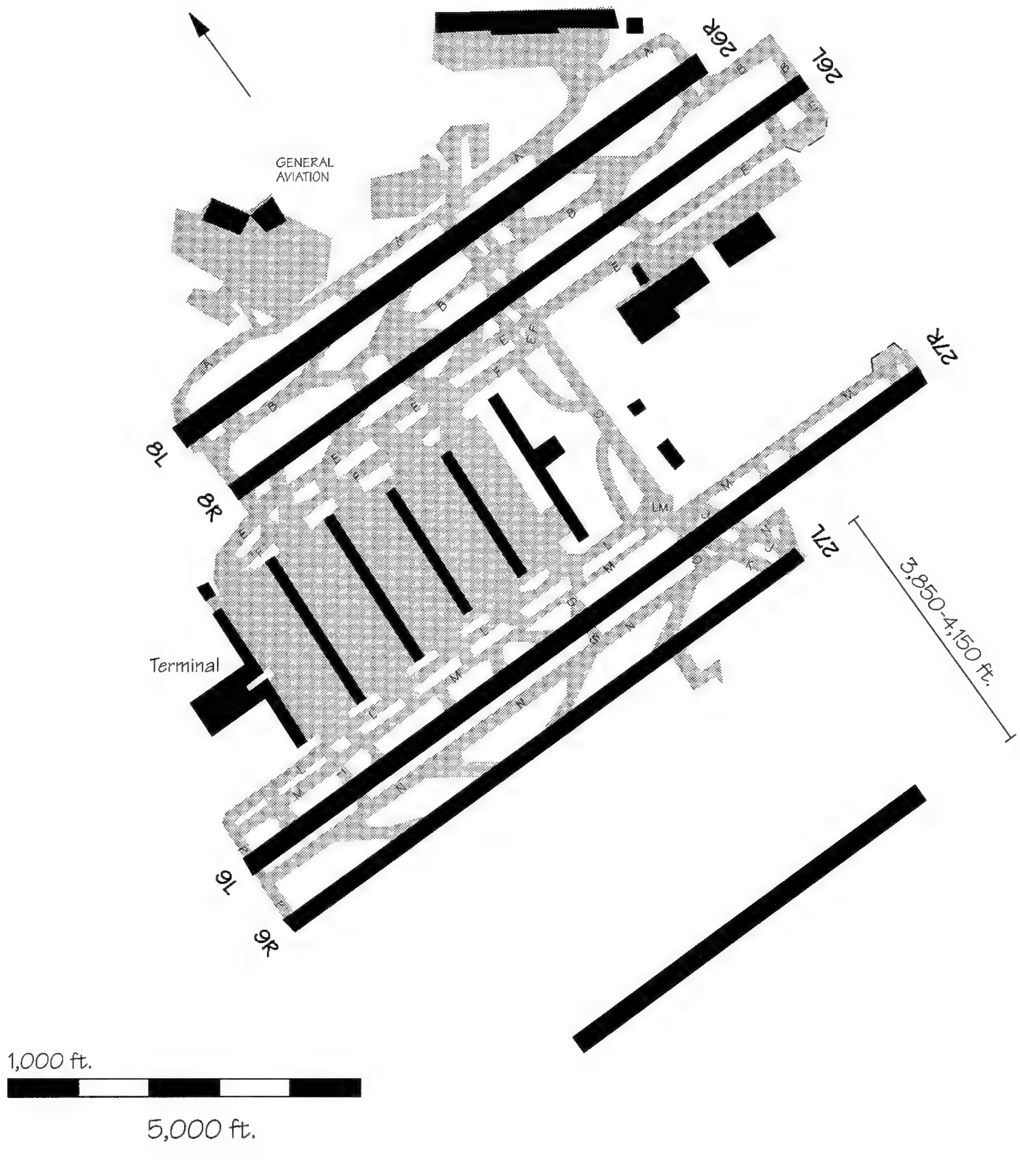
Washington Dulles Int'l Airport (IAD)

Two new parallel runways are under consideration. A north-south parallel, Runway 1W/19W, would be located 5,000 feet west of the existing parallels and north of Runway 12/30. Estimated opening date is 2009. This could provide triple independent parallel approaches, if they are approved. A second parallel Runway 12R/30L has been proposed for location 3,000 feet southwest of Runway 12/30. The runway is expected to be completed by 2010. The estimated total cost of construction is $140 million for both runways.



William B. Hartsfield Atlanta Int'l Airport (ATL)

A fifth parallel runway, 6,000 feet long and 3,850 to 4,150 feet south of Runway 9R/27L, is being planned. The runway will permit triple independent IFR approaches using the PRM. The total estimated cost is $160 million. The estimated operational date is 1999.

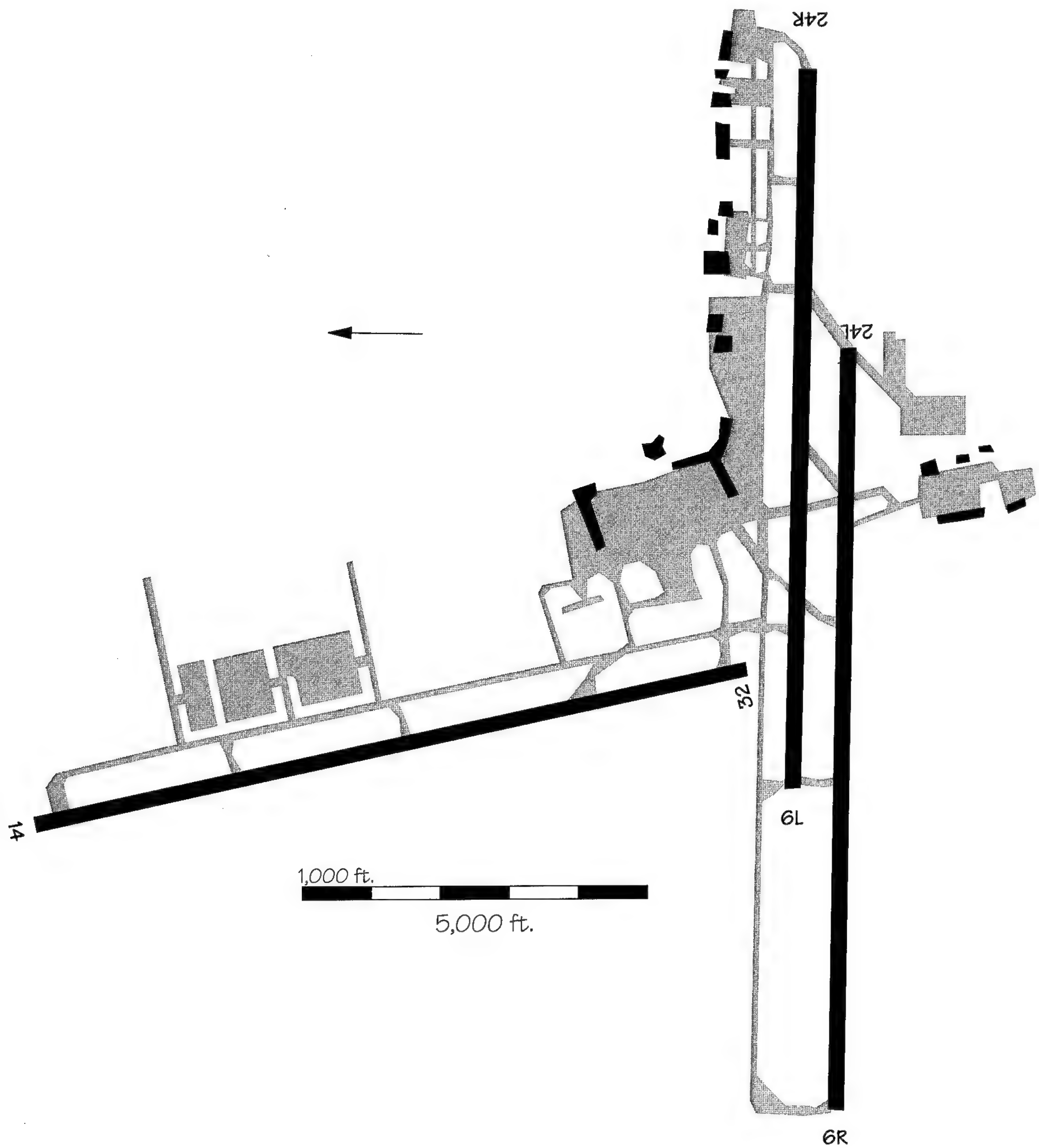


Appendix E

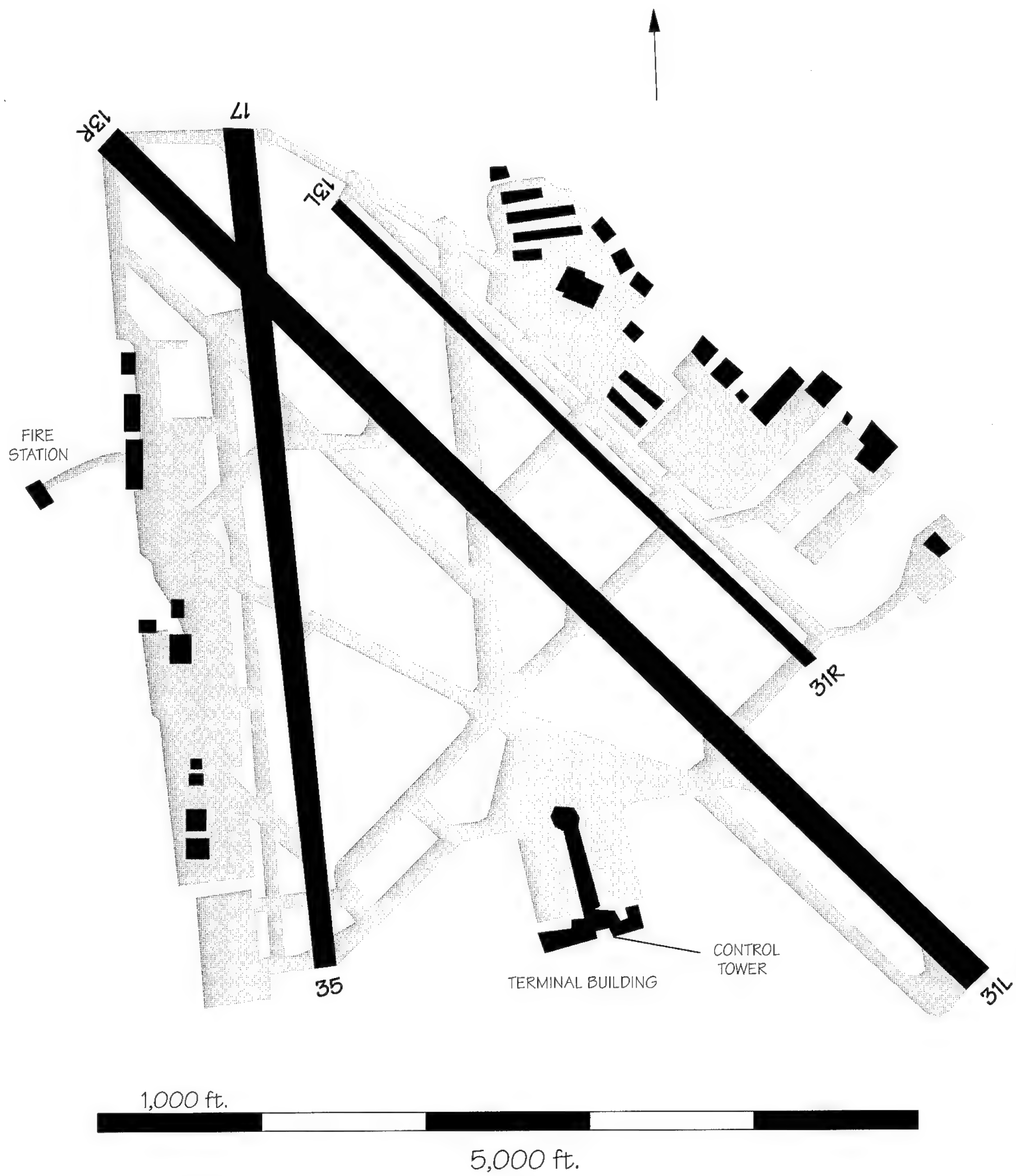
Layouts of the Remaining Top 100 Airports

Appendix E contains current airport layouts for those airports among the top 100 airports[1] that are not considering construction of new runways or extensions to existing runways at the present time. The airport layouts show simplified drawings of the existing airports. Airport layouts for those airports that are considering or have plans for new runways or runway extension projects are contained in Appendix D.

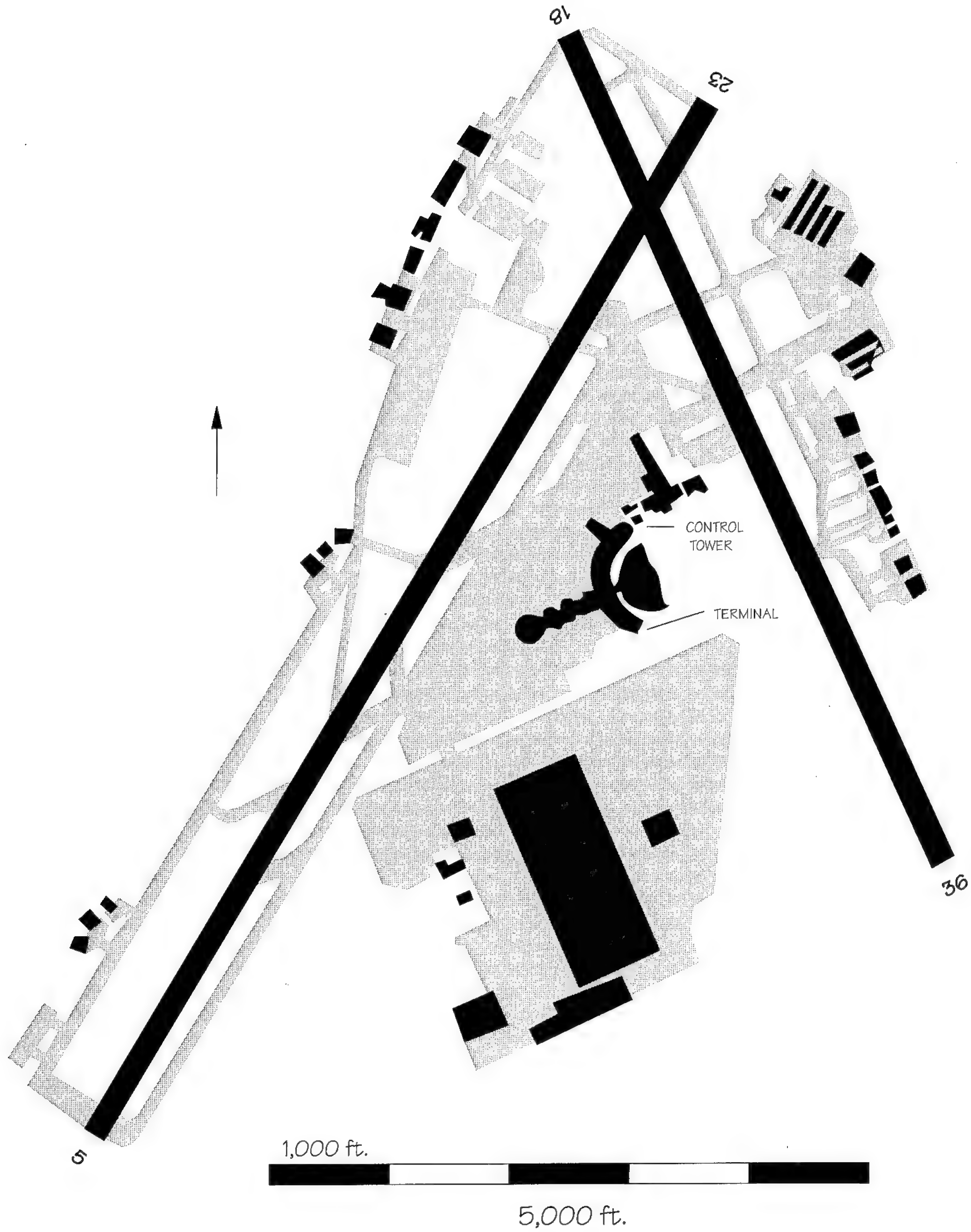
1. Based on 1992 passenger enplanements (see Appendix A, Table A-1).



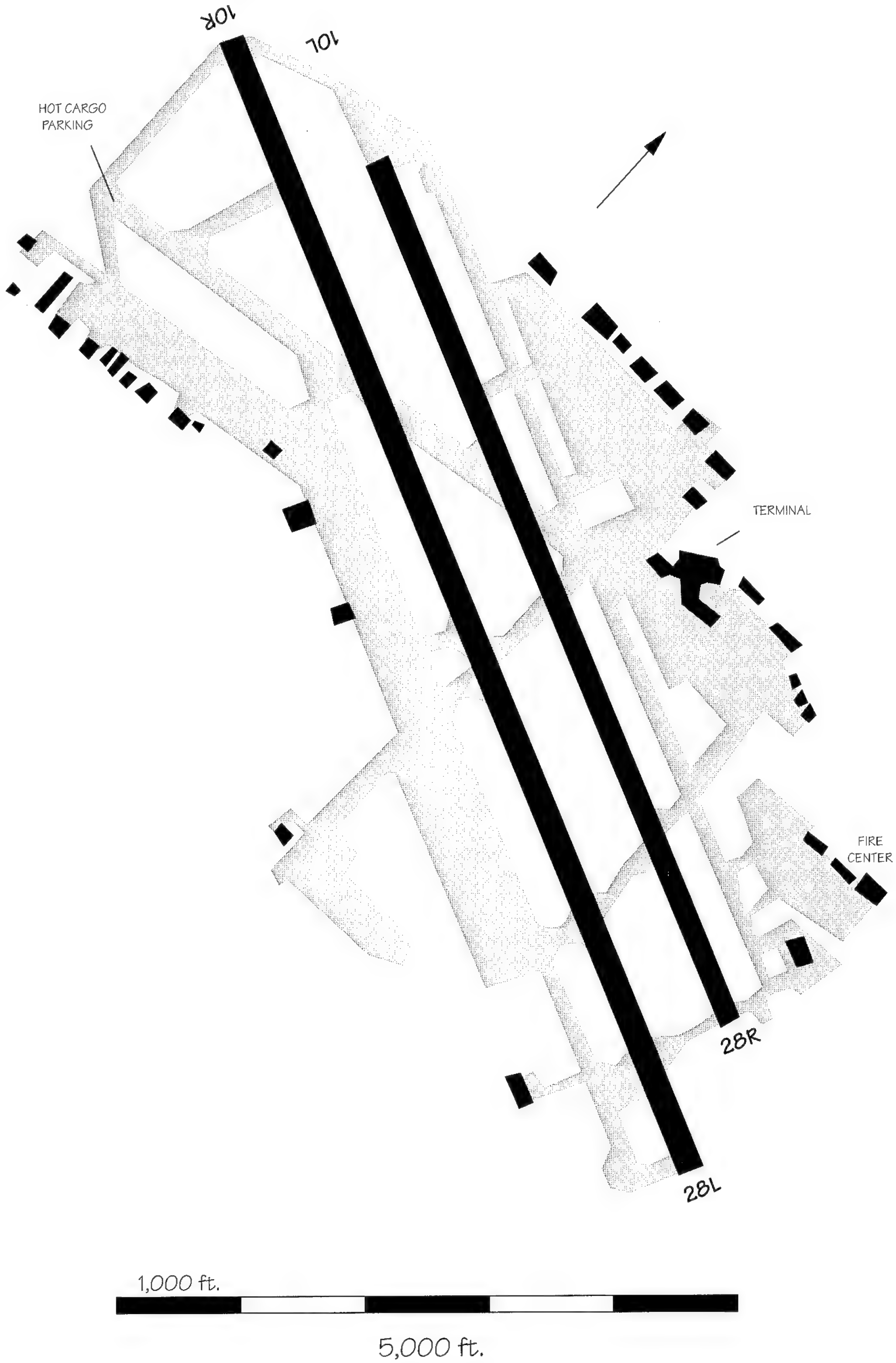
Anchorage International Airport (ANC)



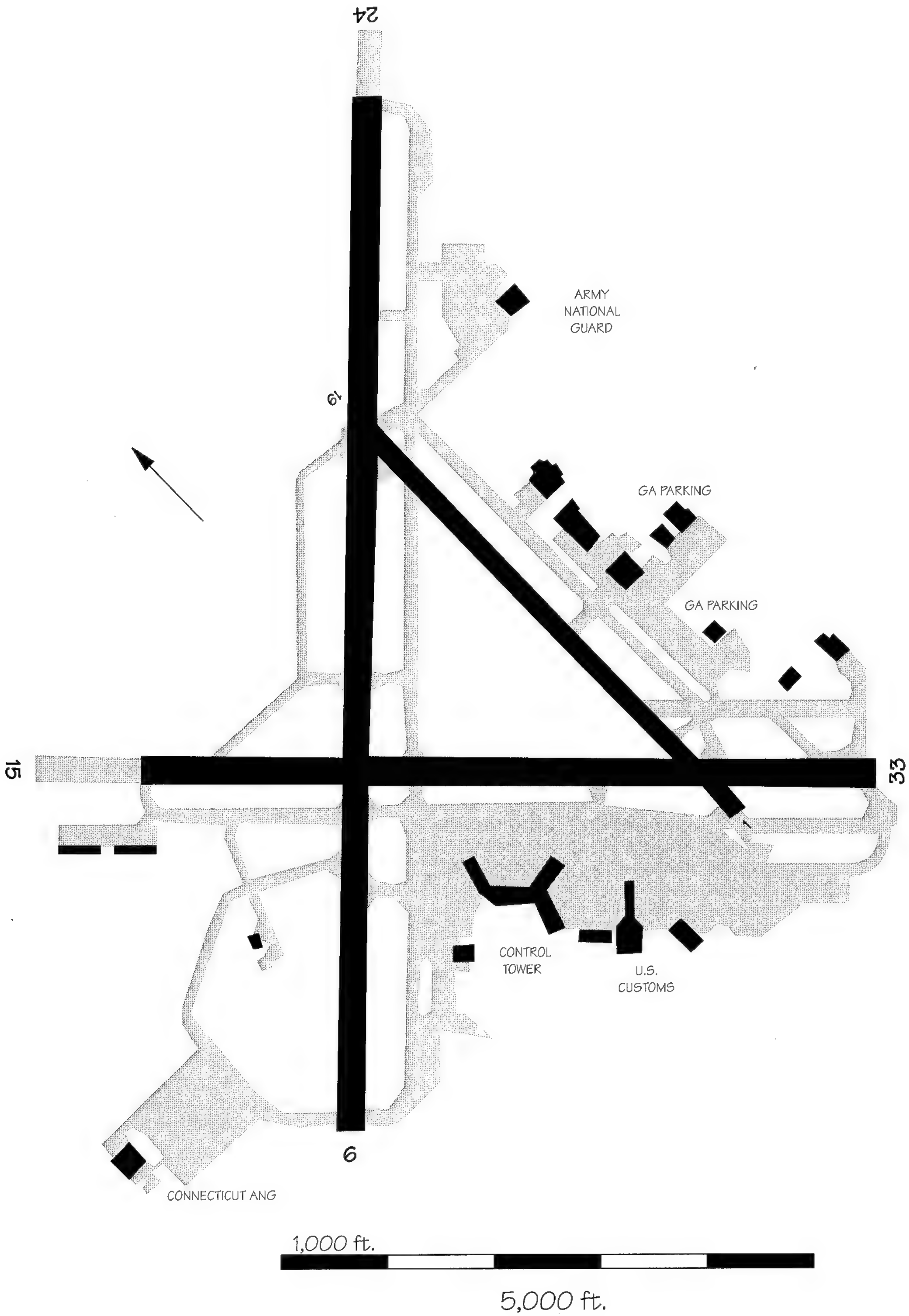
Austin Robert Mueller Municipal Airport (AUS)



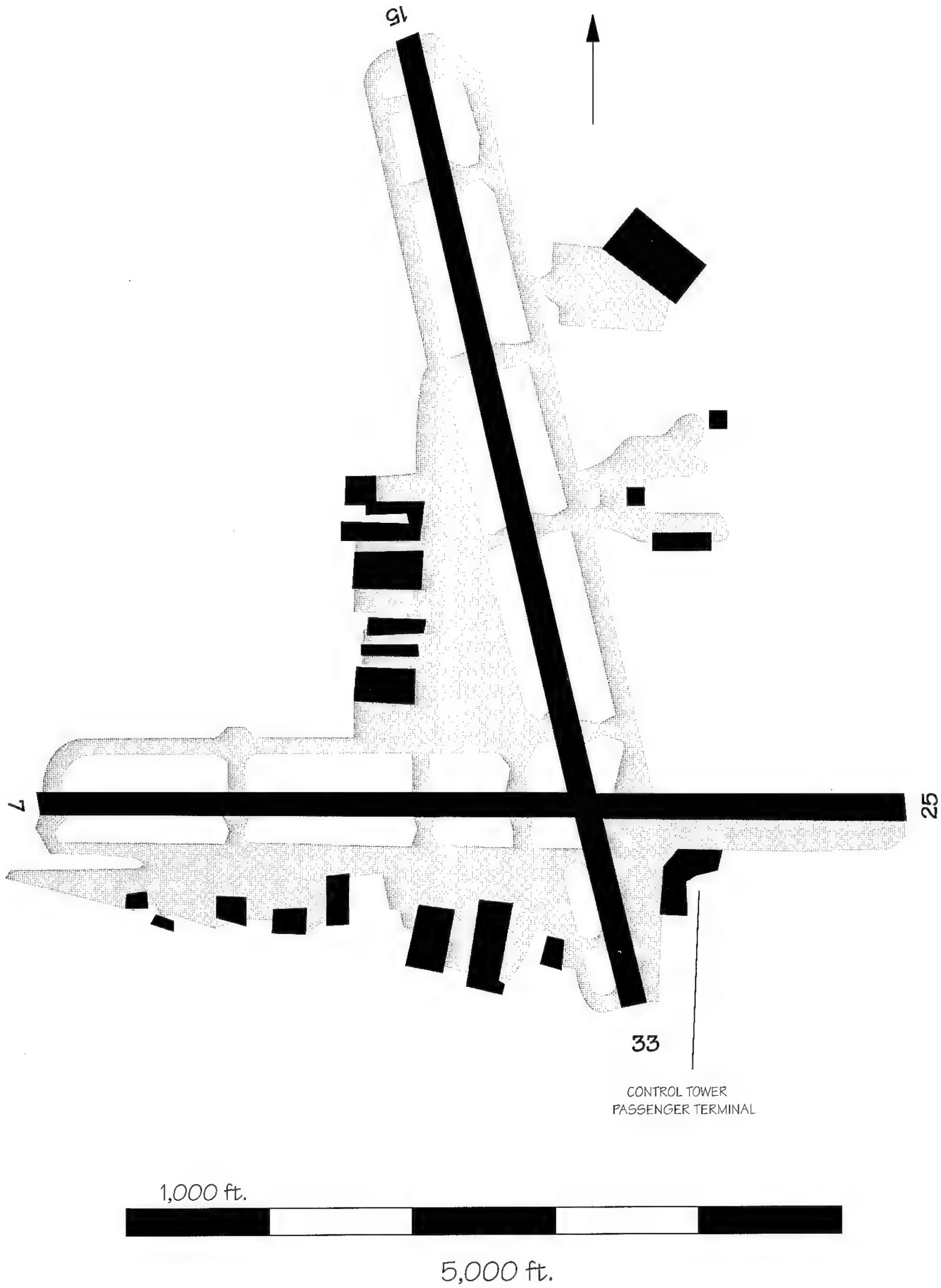
Birmingham Airport (BHM)



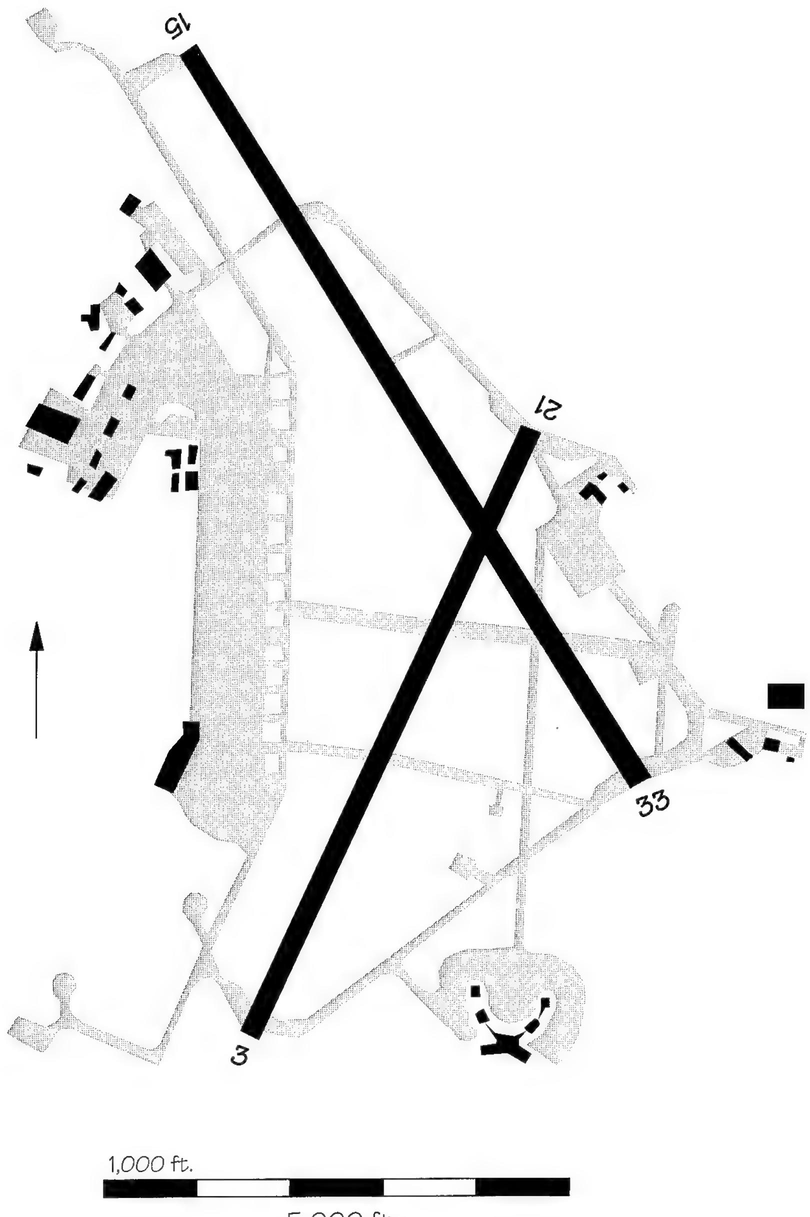
Boise Air Terminal (BOI)



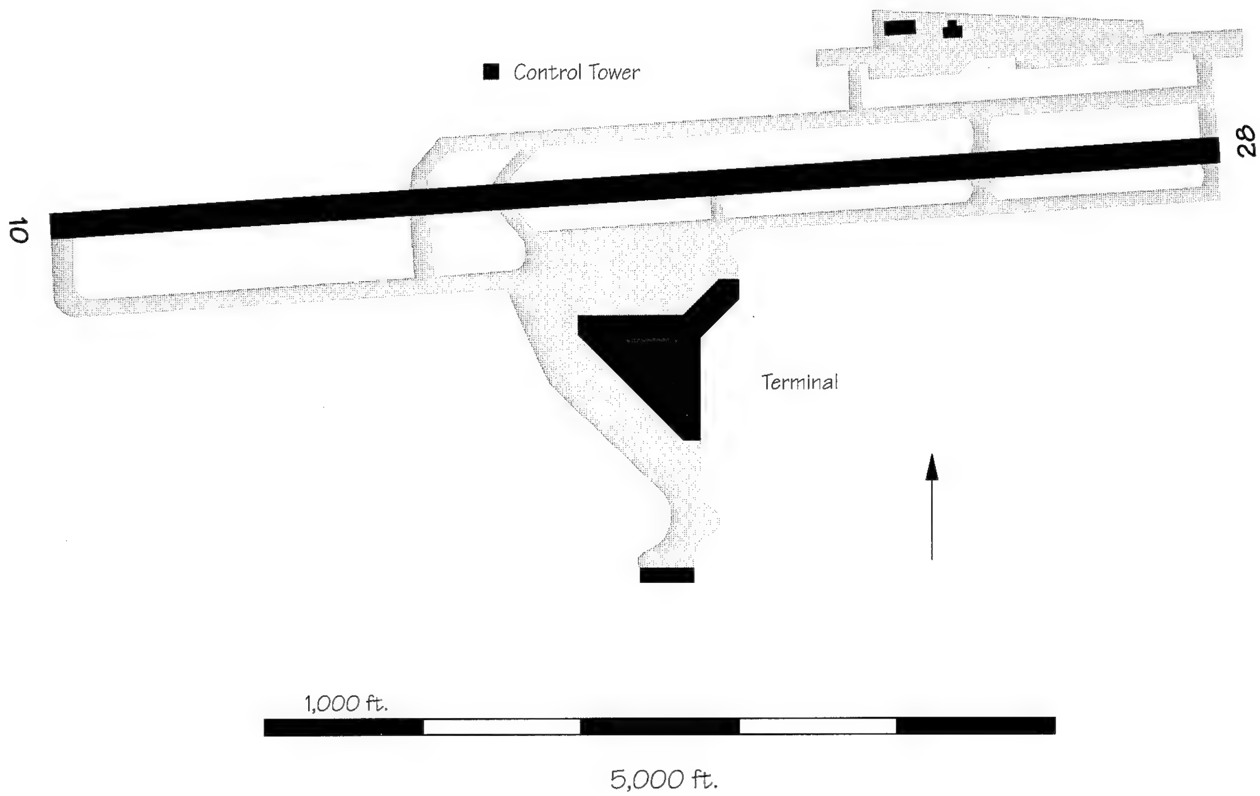
Bradley International Airport (BDL)



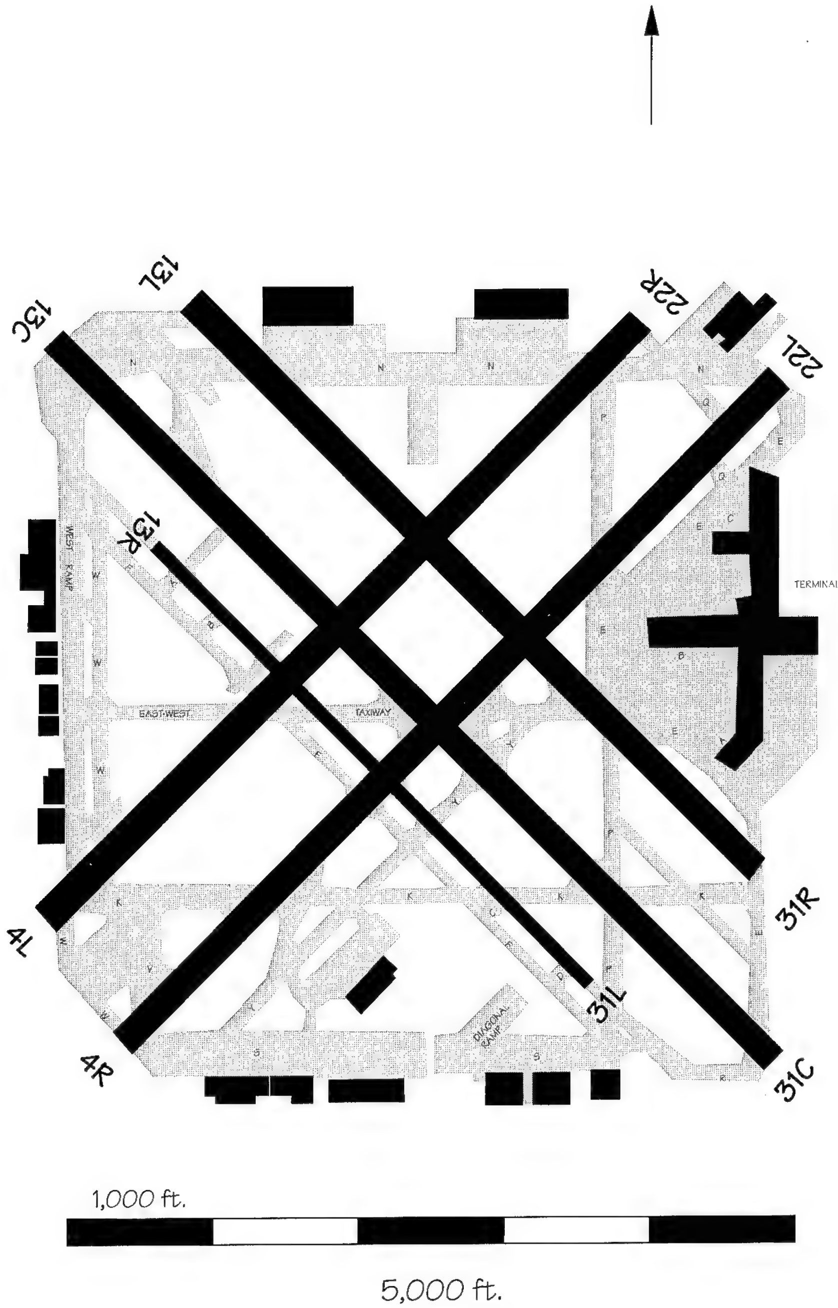
Burbank-Glendale-Pasadena Airport (BUR)



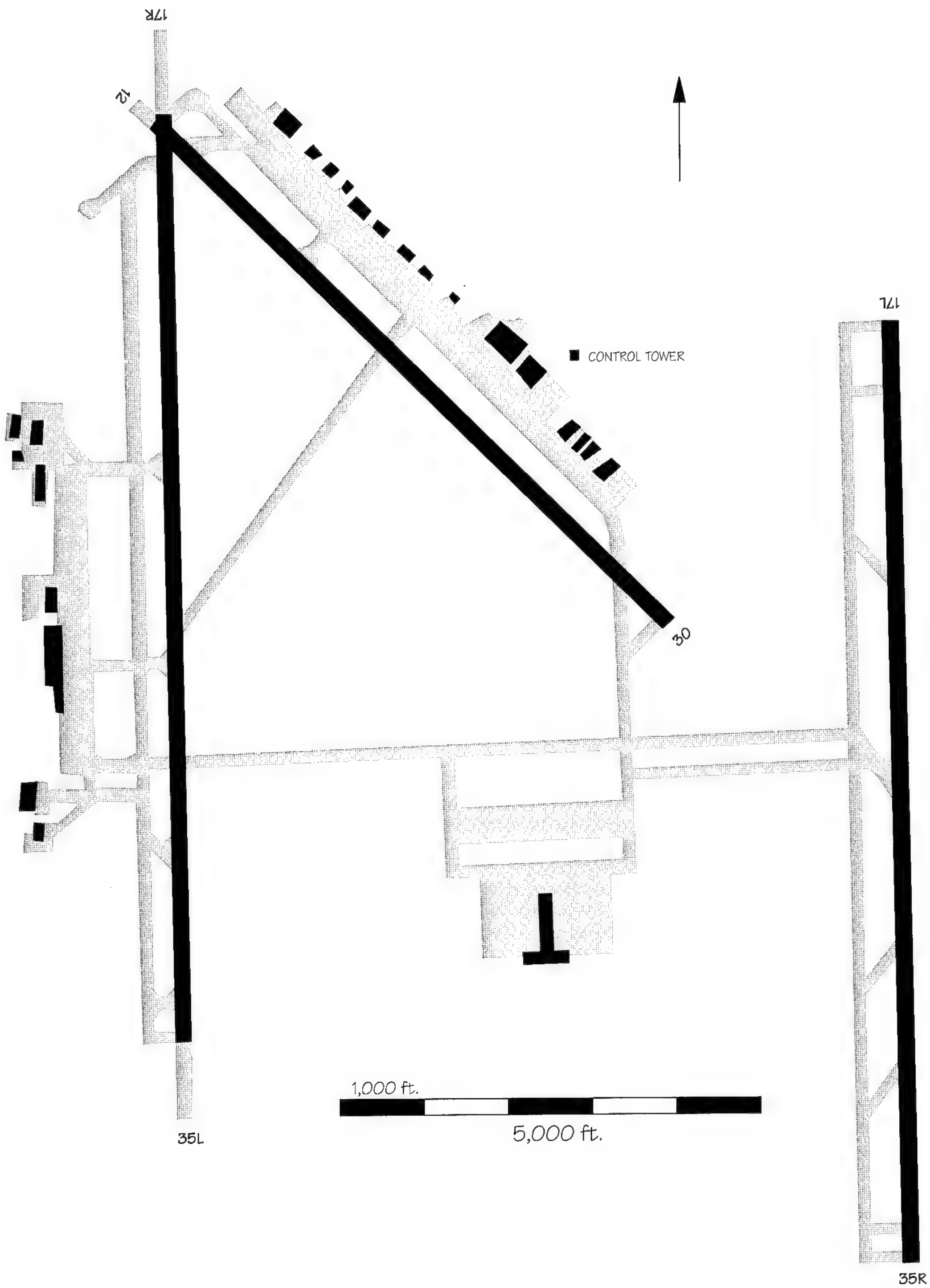
Charleston AFB International Airport (CHS)



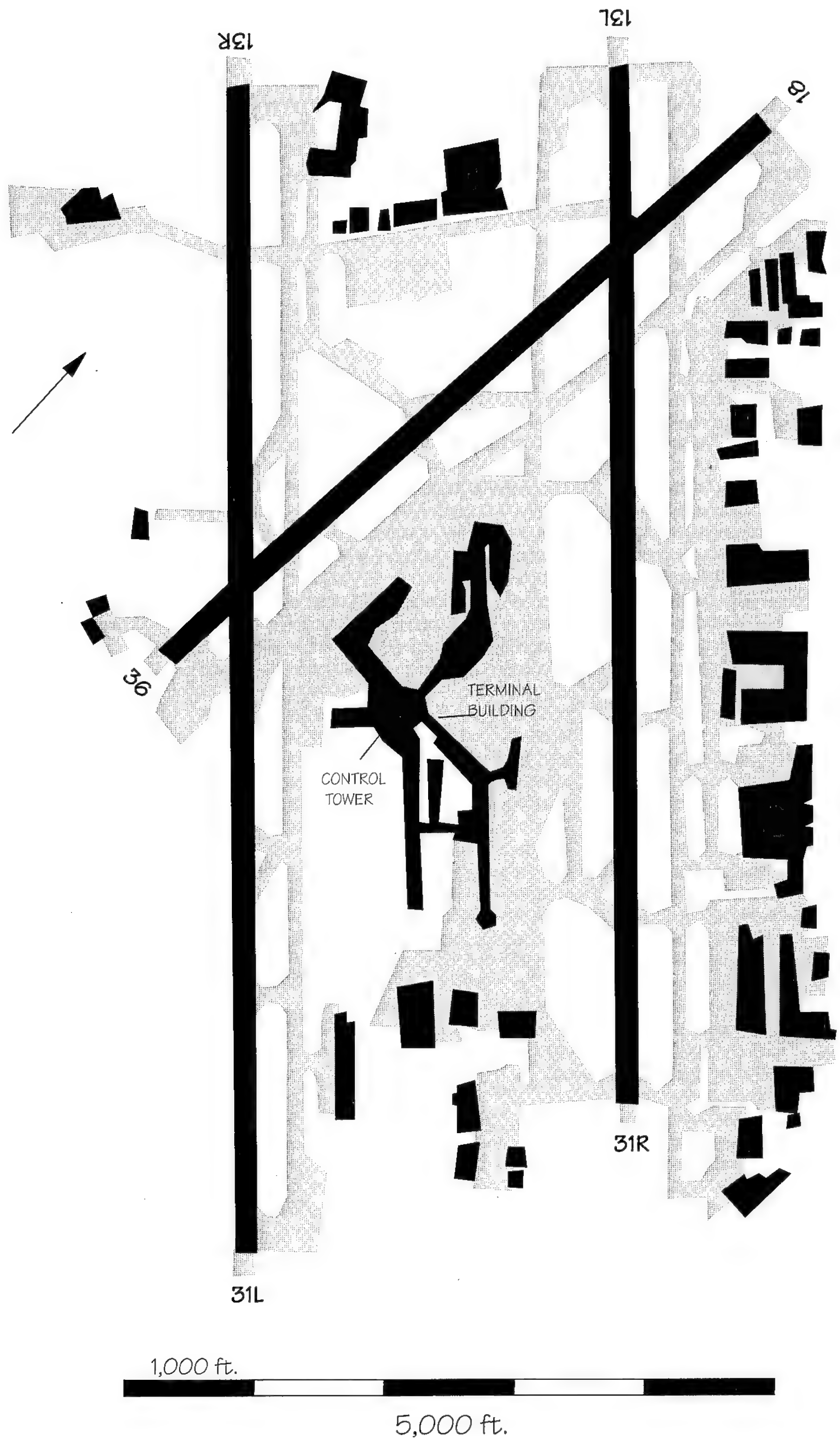
Charlotte Amalie St. Thomas, Virgin Islands (STT)



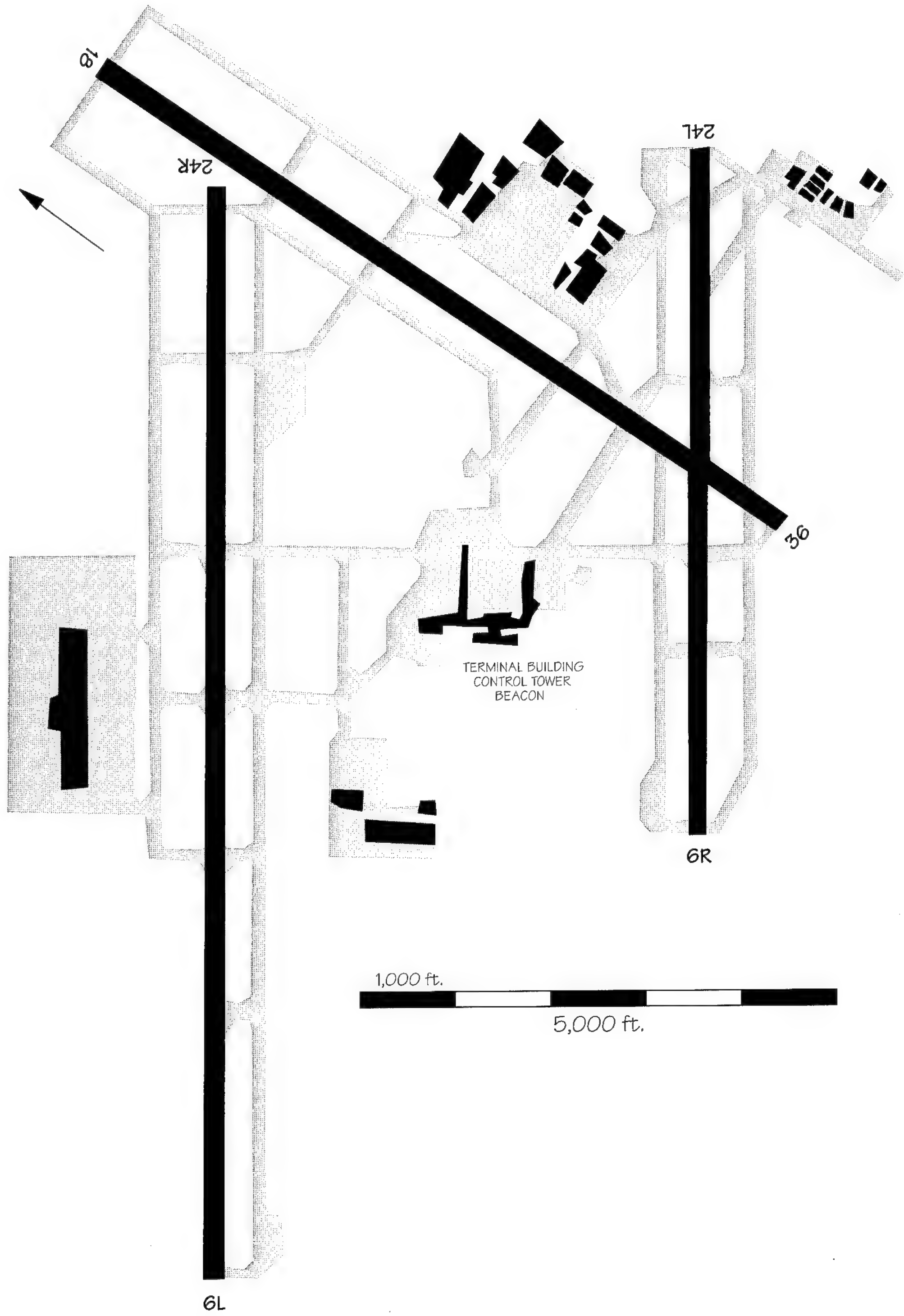
Chicago Midway Airport (MDW)



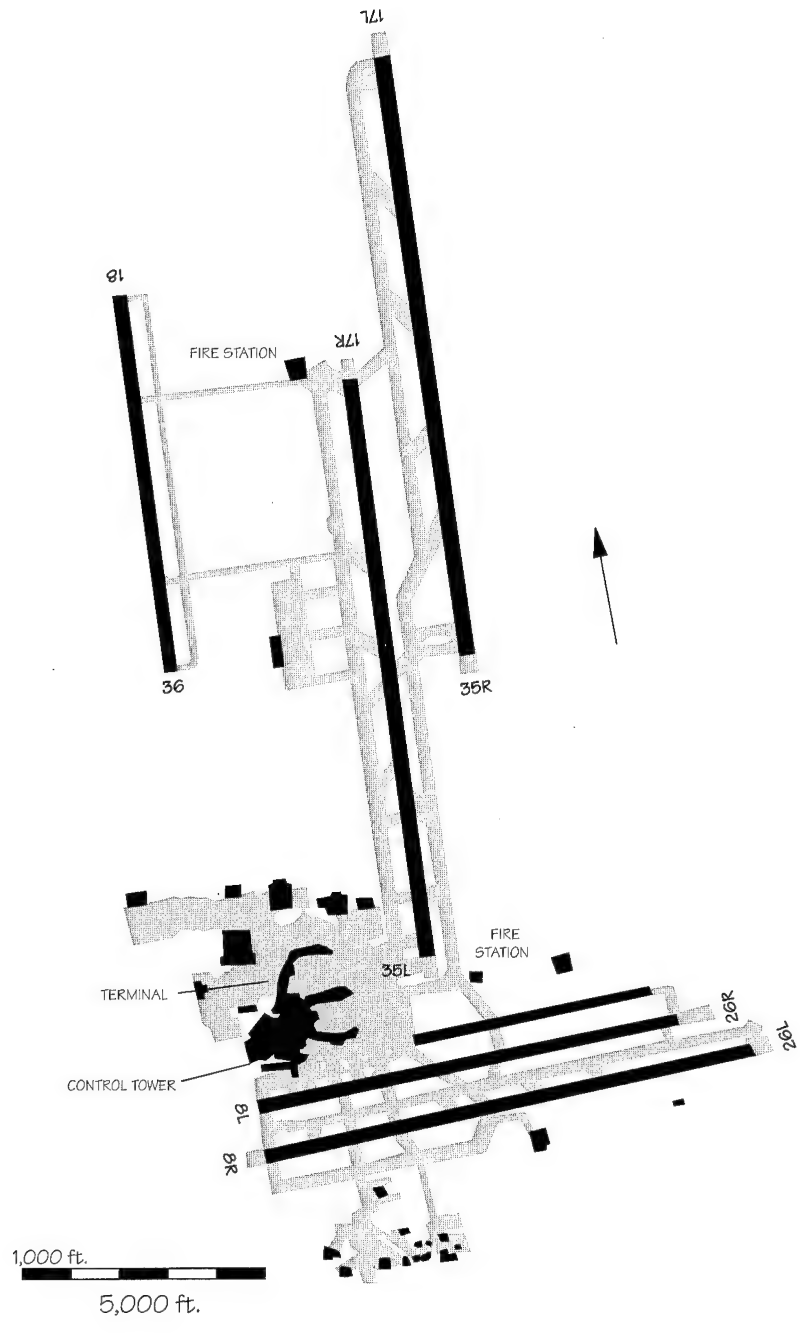
Colorado Springs Municipal Airport (COS)



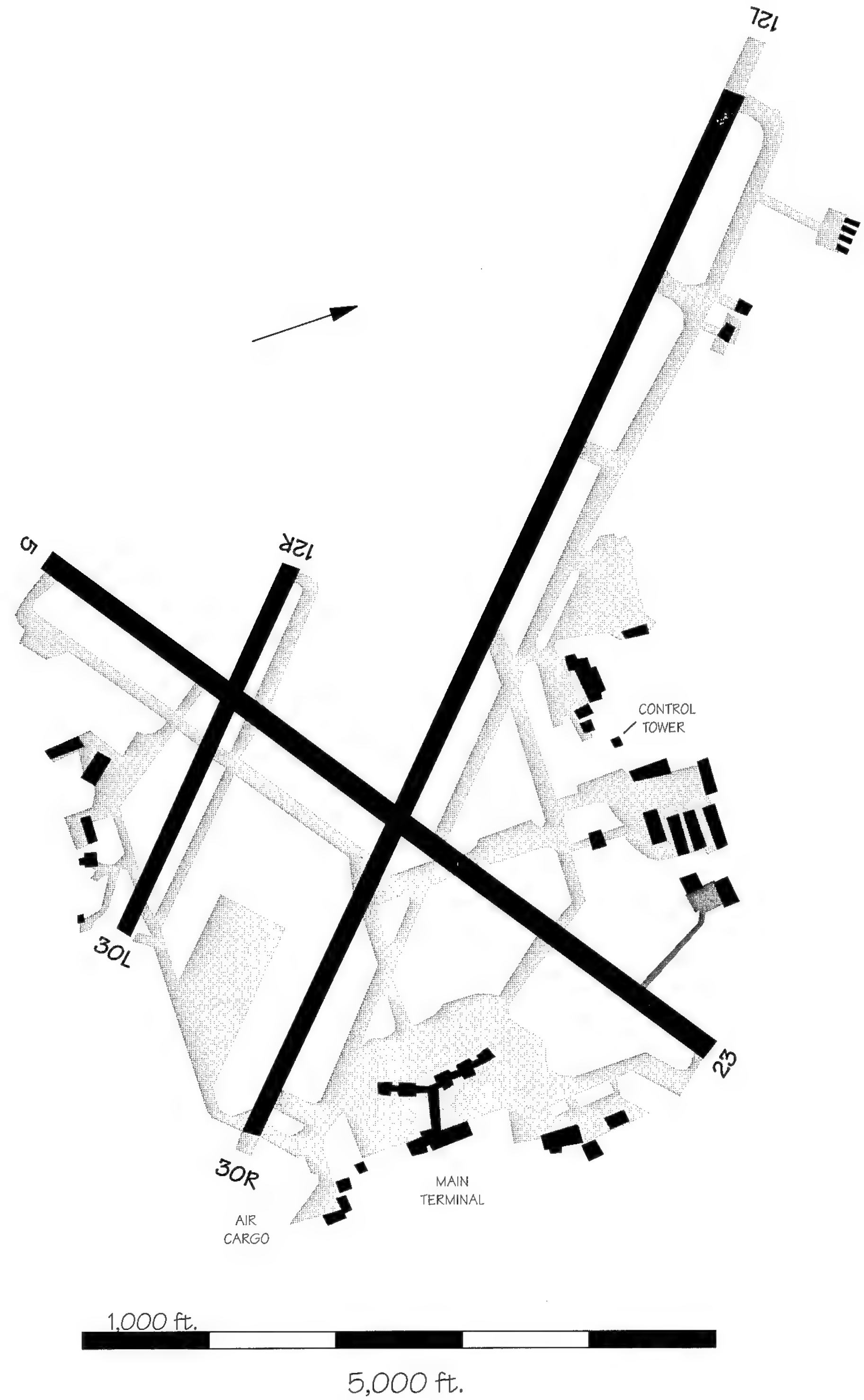
Dallas-Love Field (DAL)



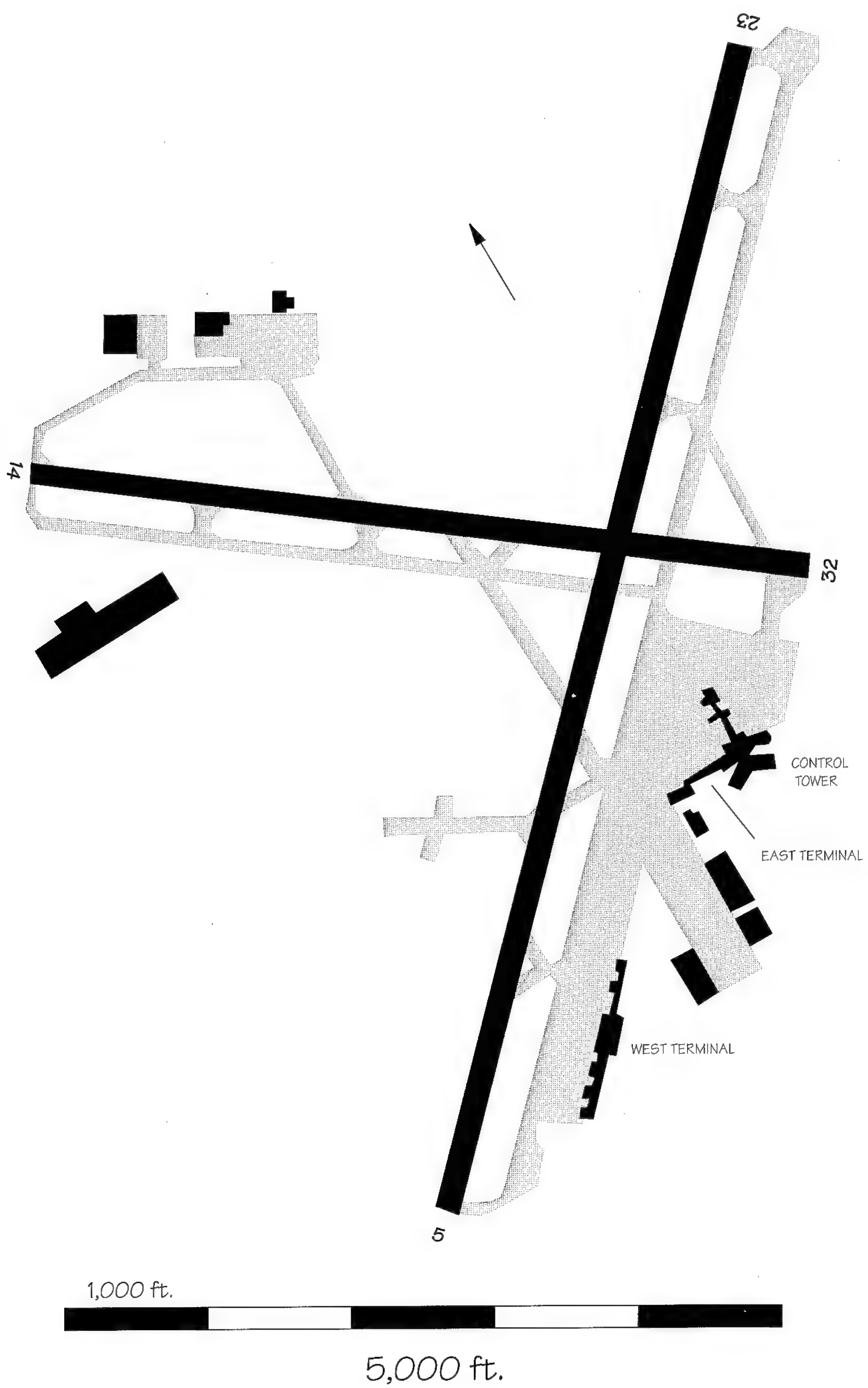
Dayton International Airport (DAY)



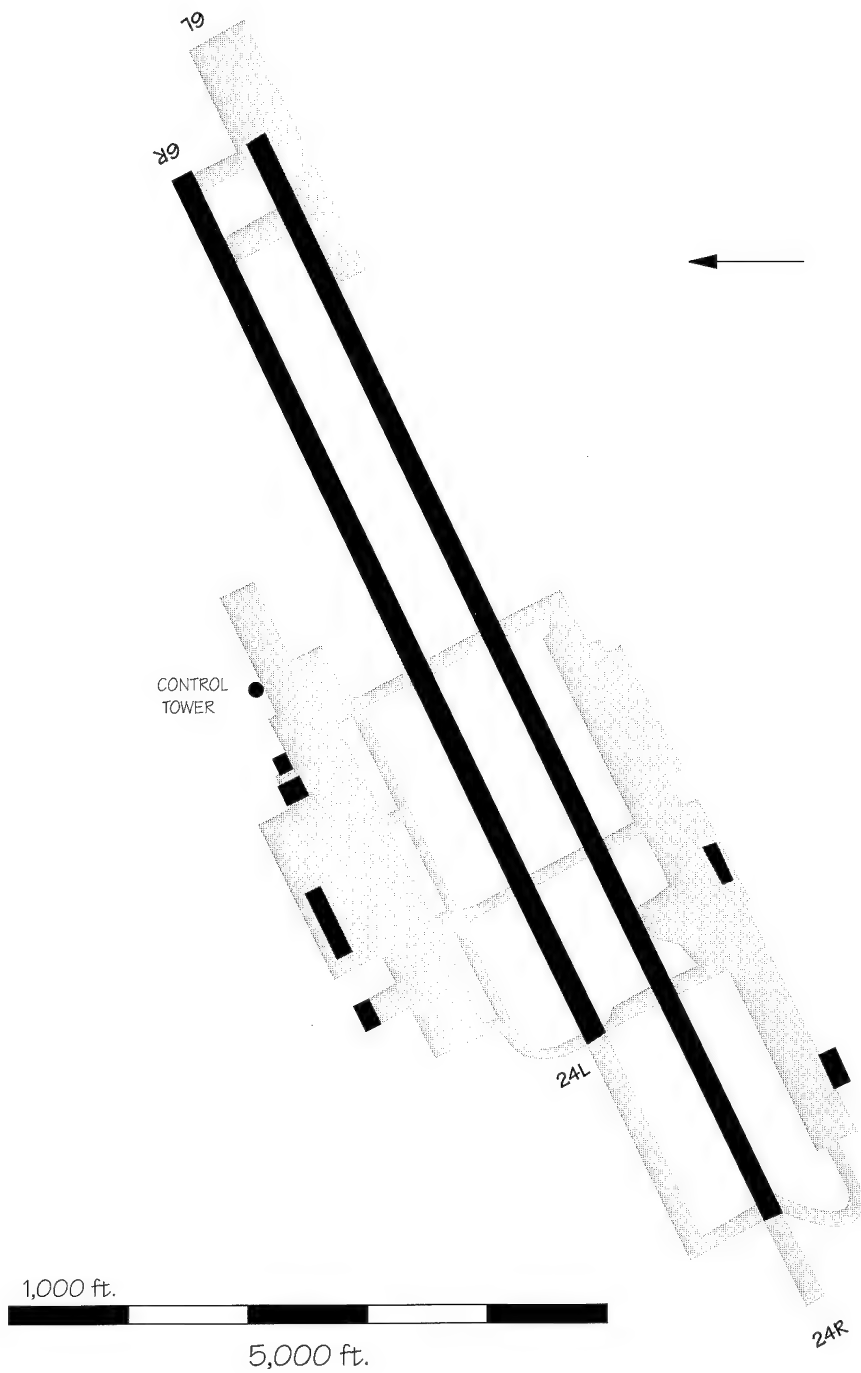
Denver Stapleton International Airport (DEN)



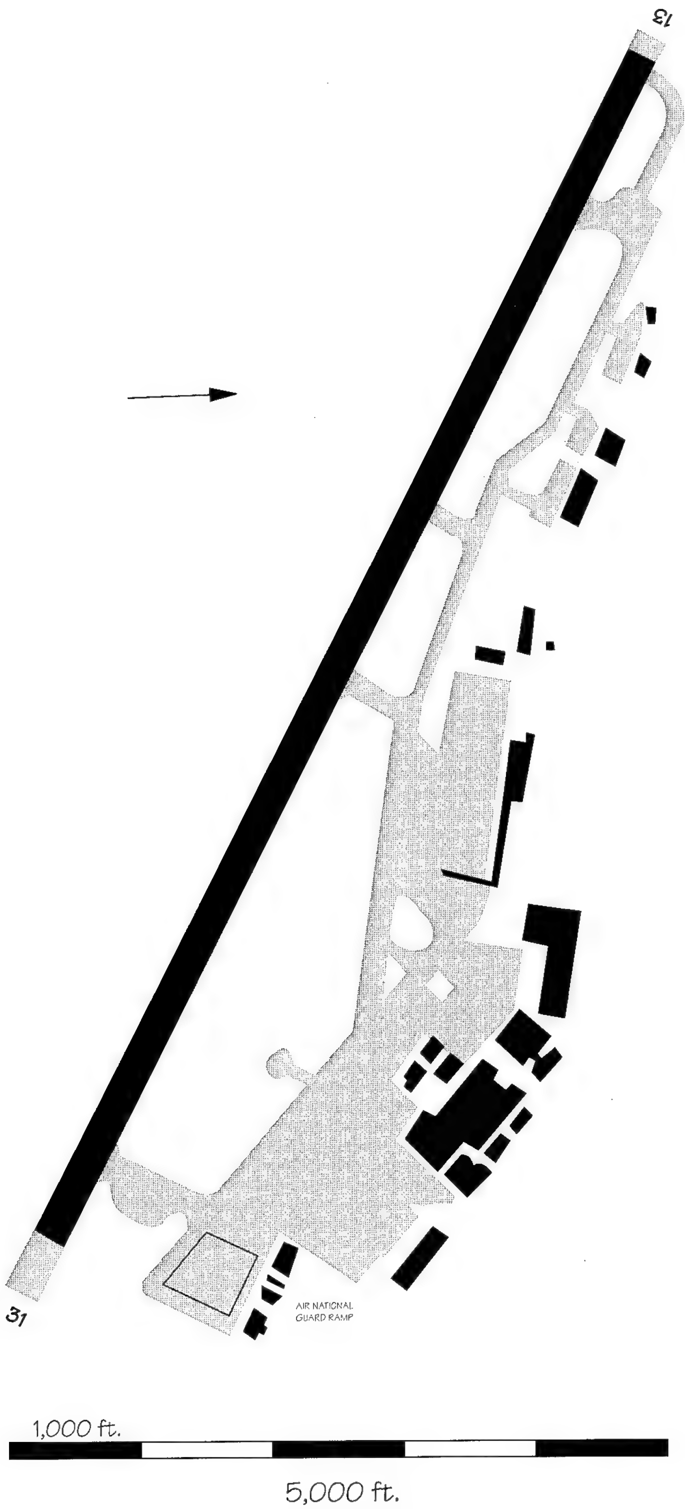
Des Moines International Airport (DSM)



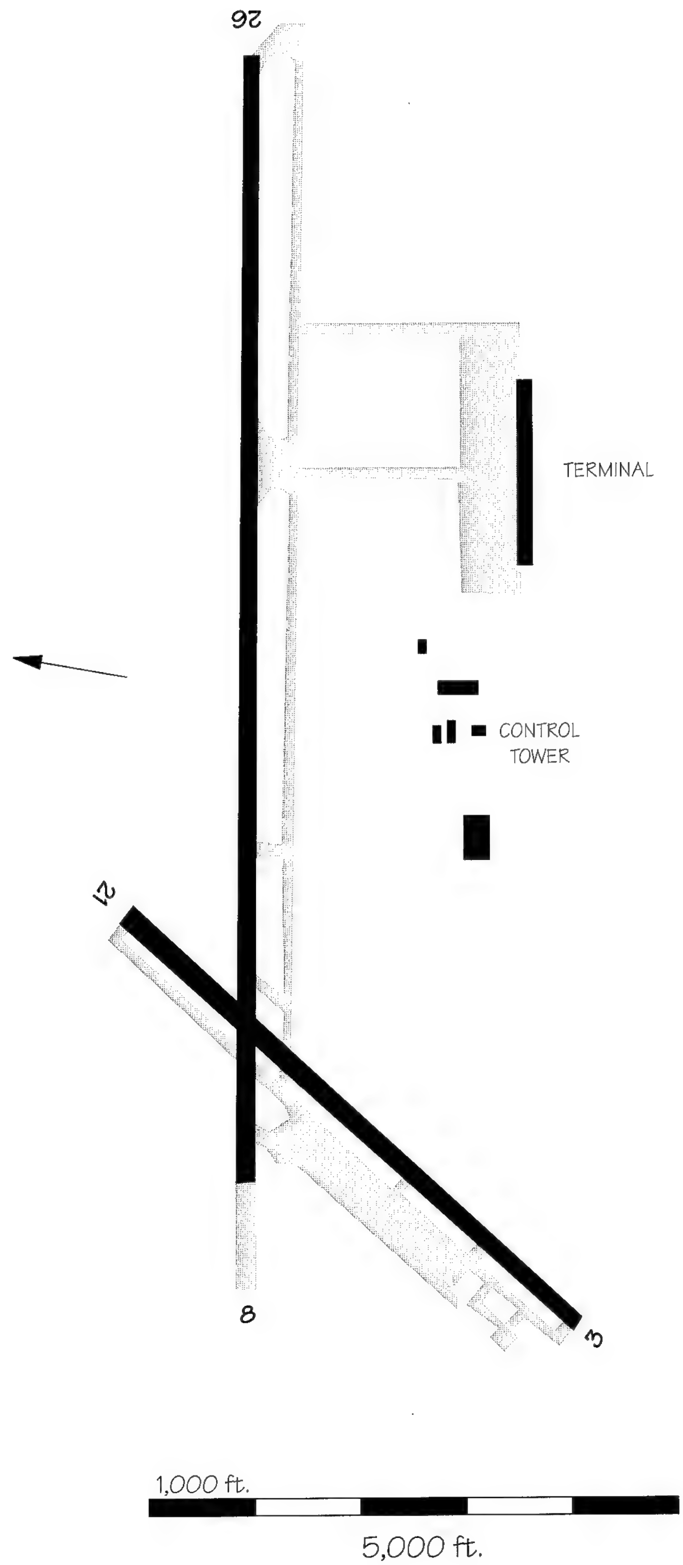
Greater Buffalo International Airport (BUF)



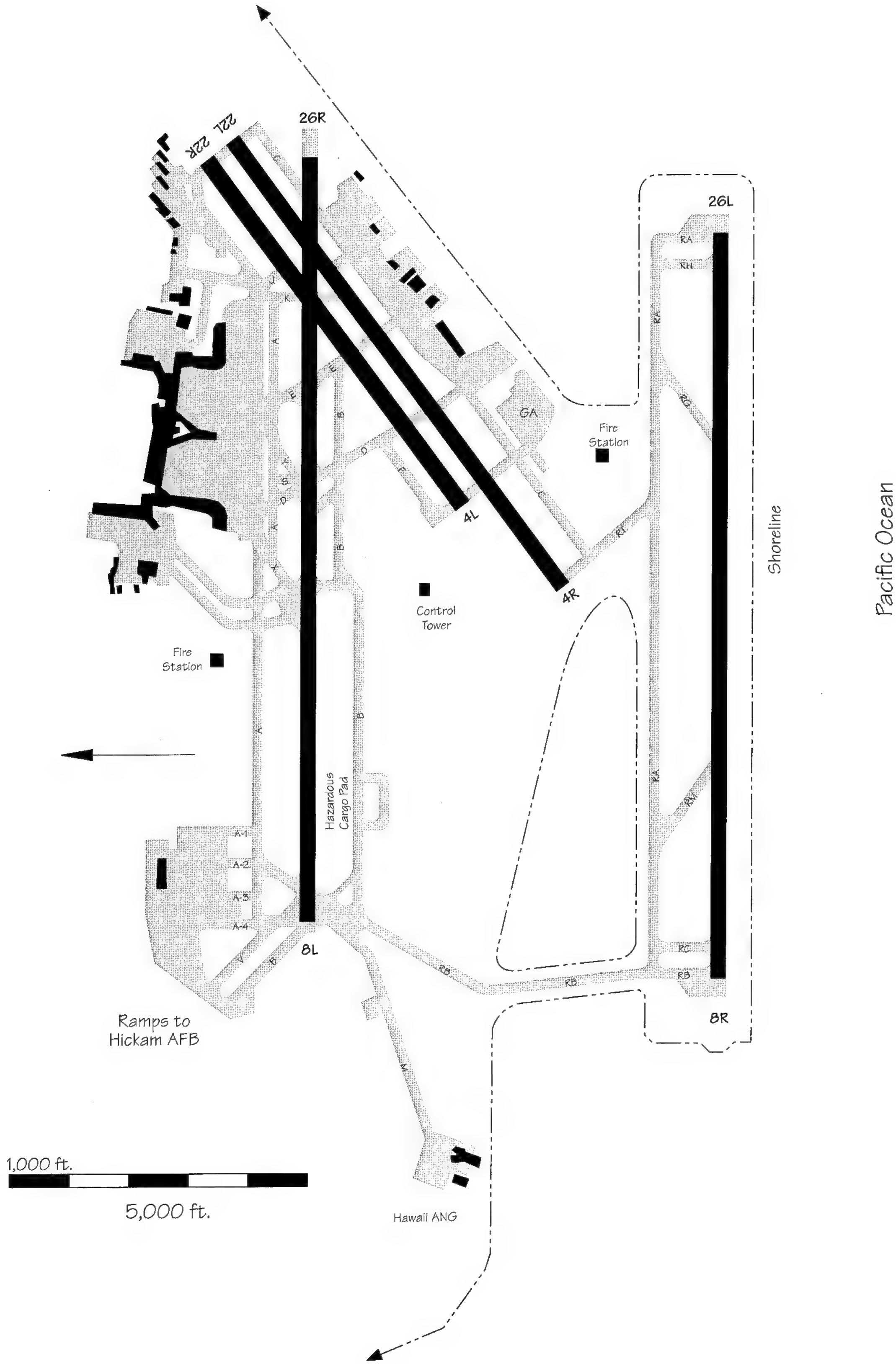
Guam Agana Field (NGM)



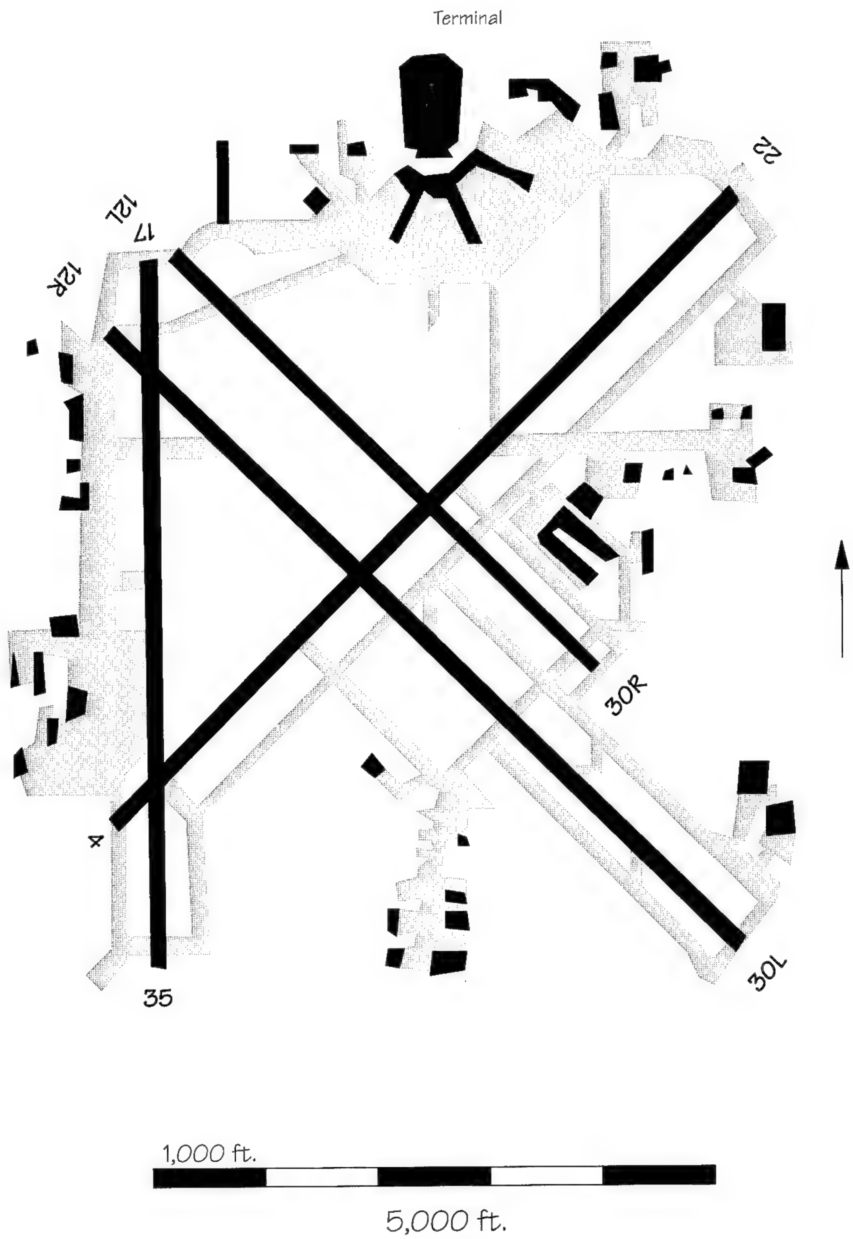
Harrisburg International Airport (MDT)



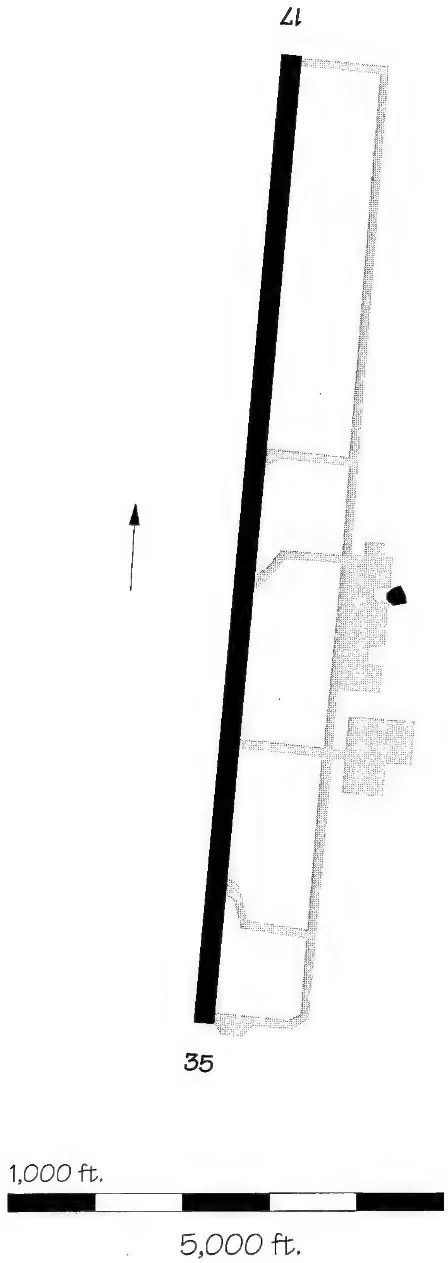
Hilo International Airport (ITO)



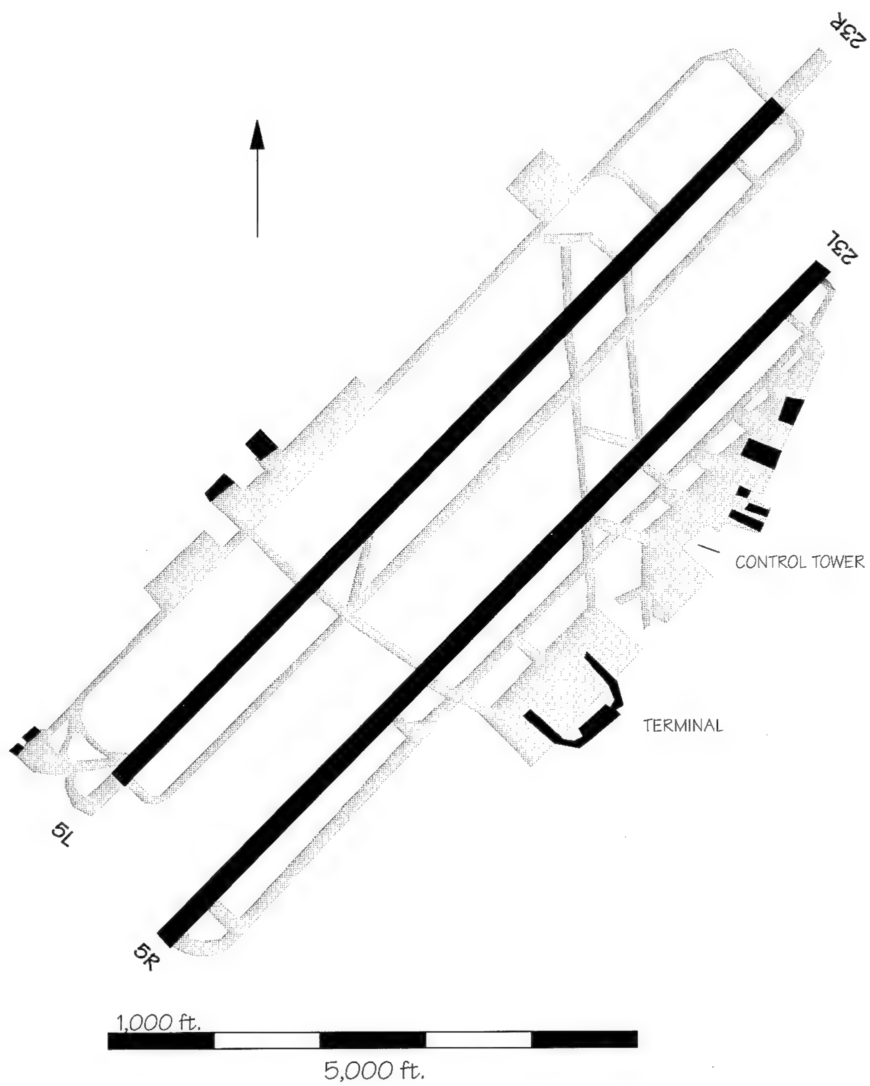
Honolulu International Airport (HNL)



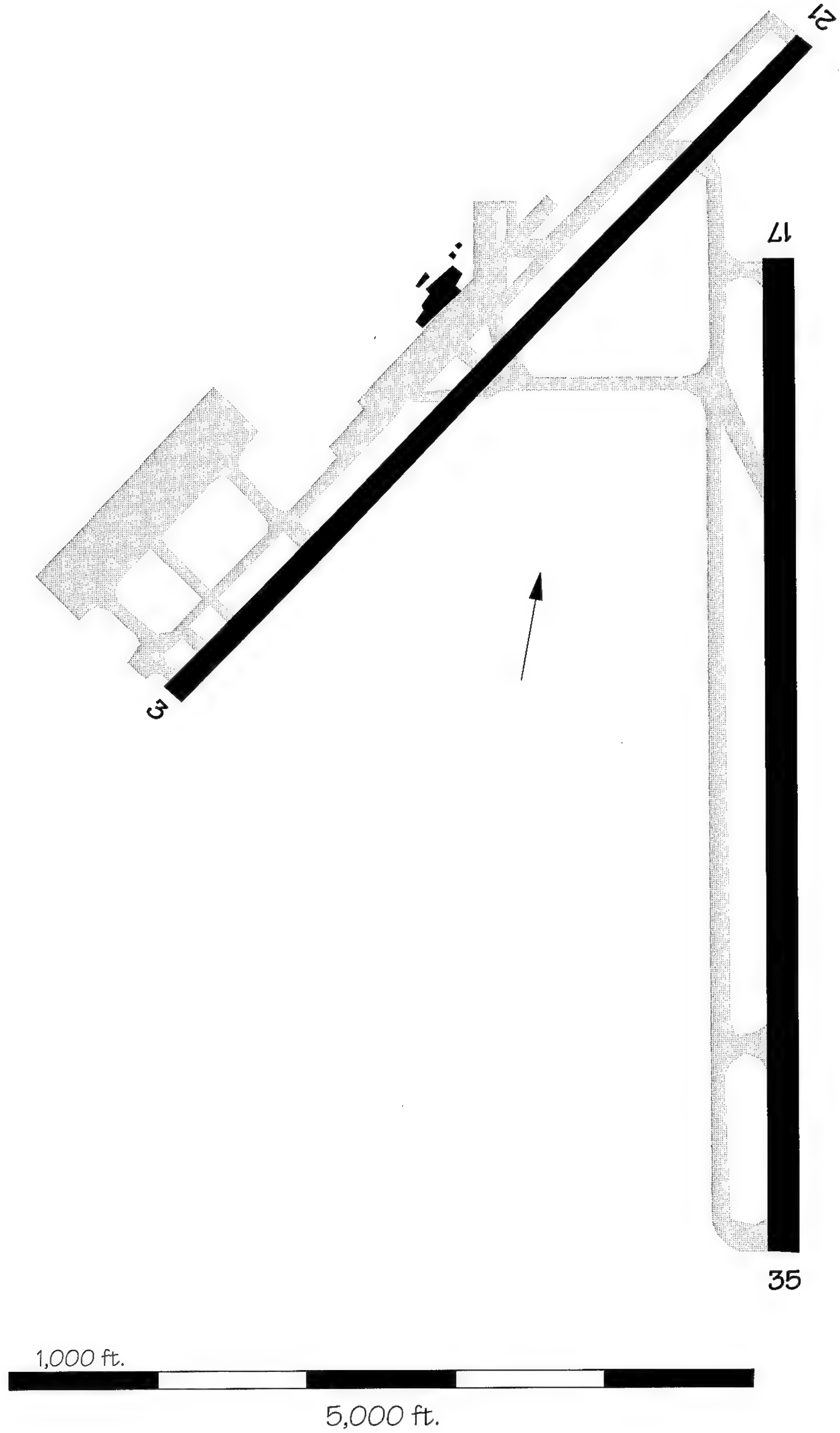
Houston William P. Hobby Airport (HOU)



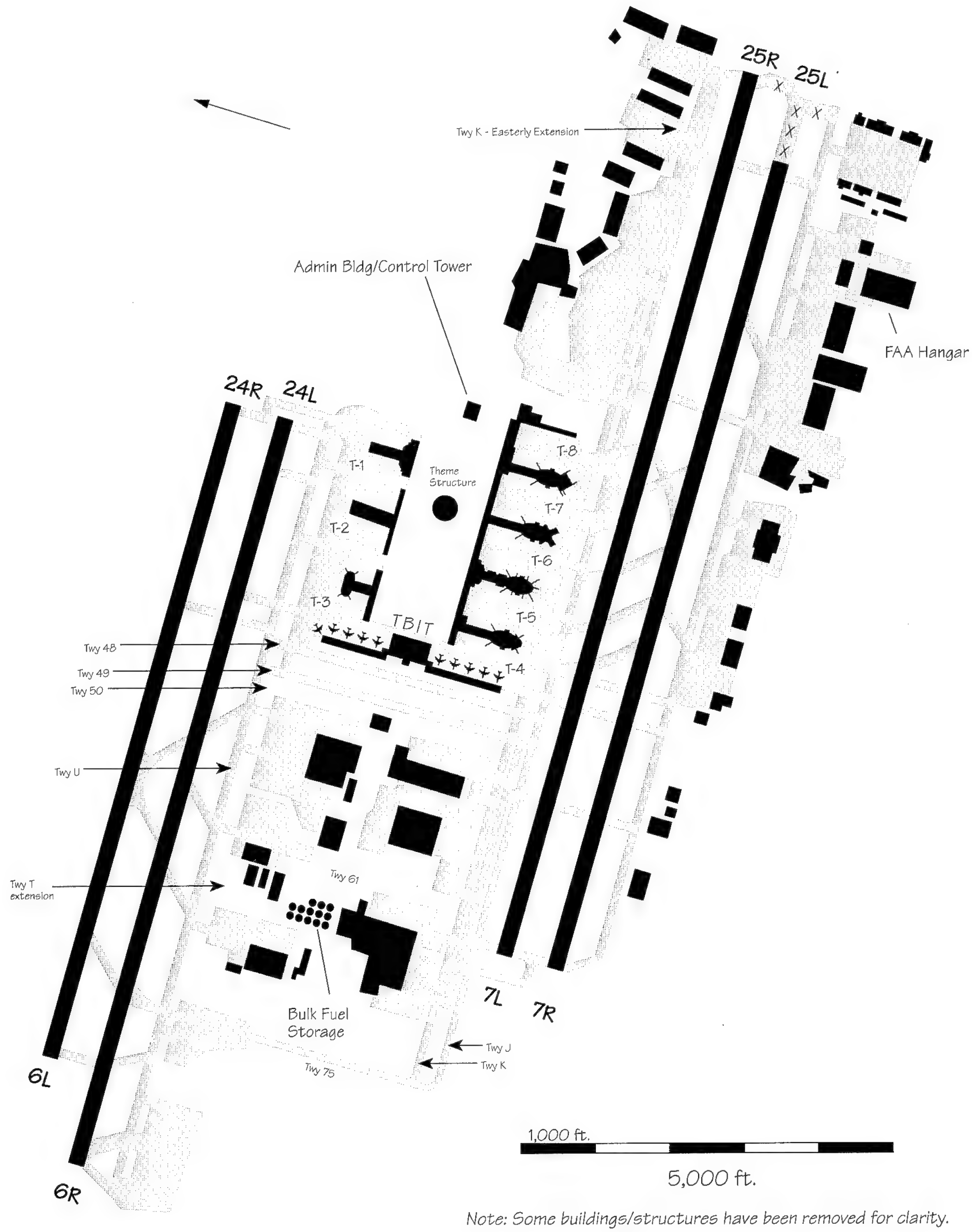
Kailua-Kona Keahole Airport (KOA)



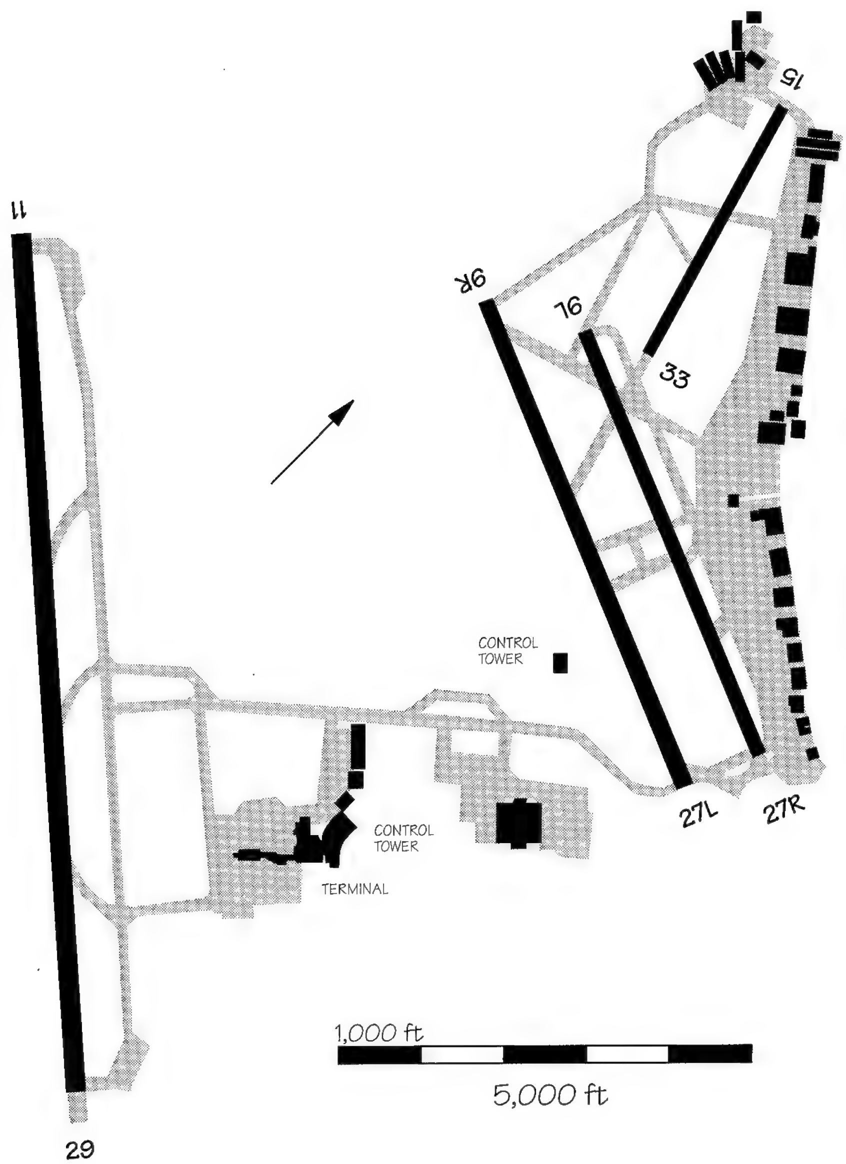
Knoxville McGhee-Tyson Airport (TYS)



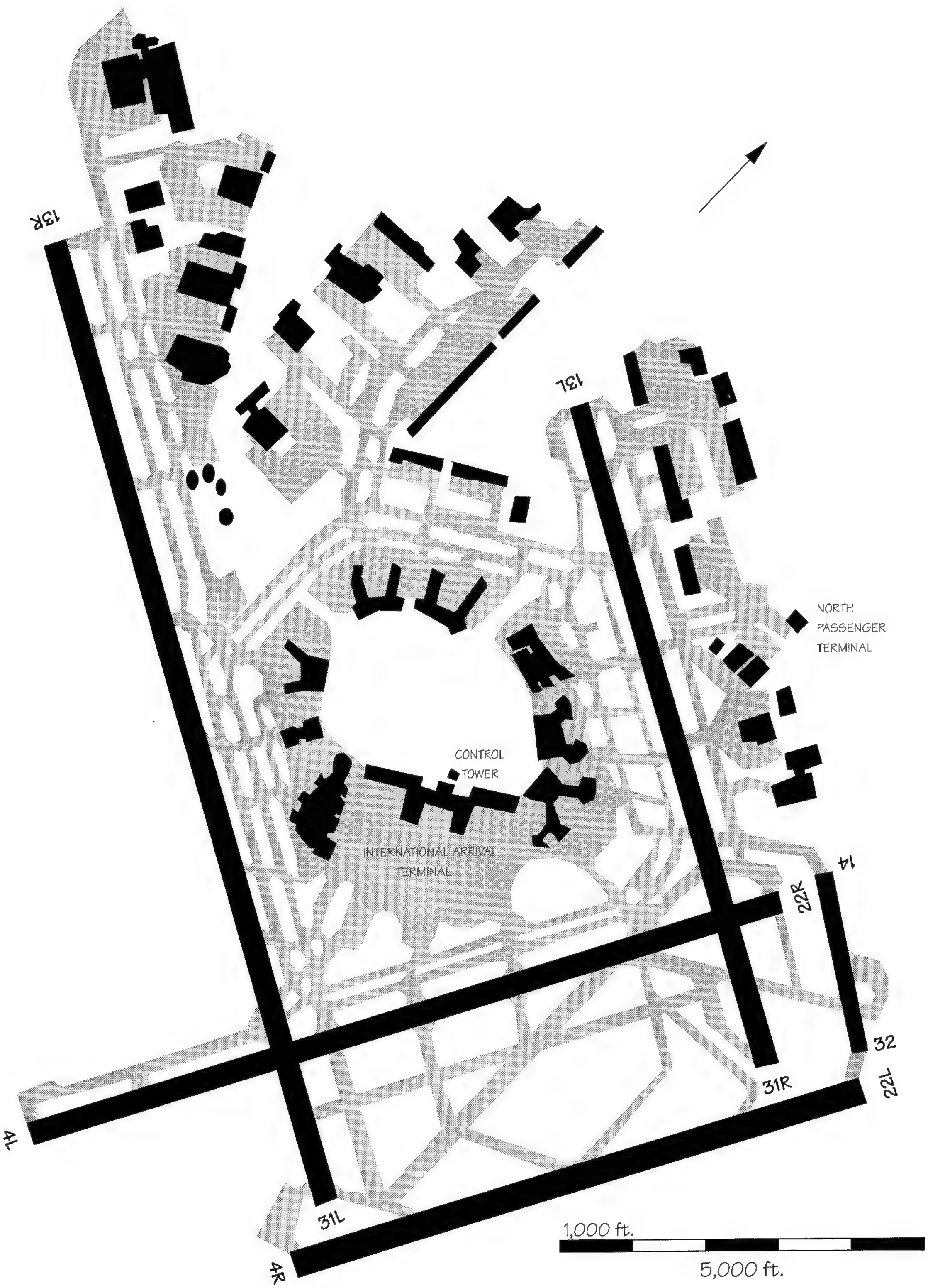
Lihue Airport (LIH)



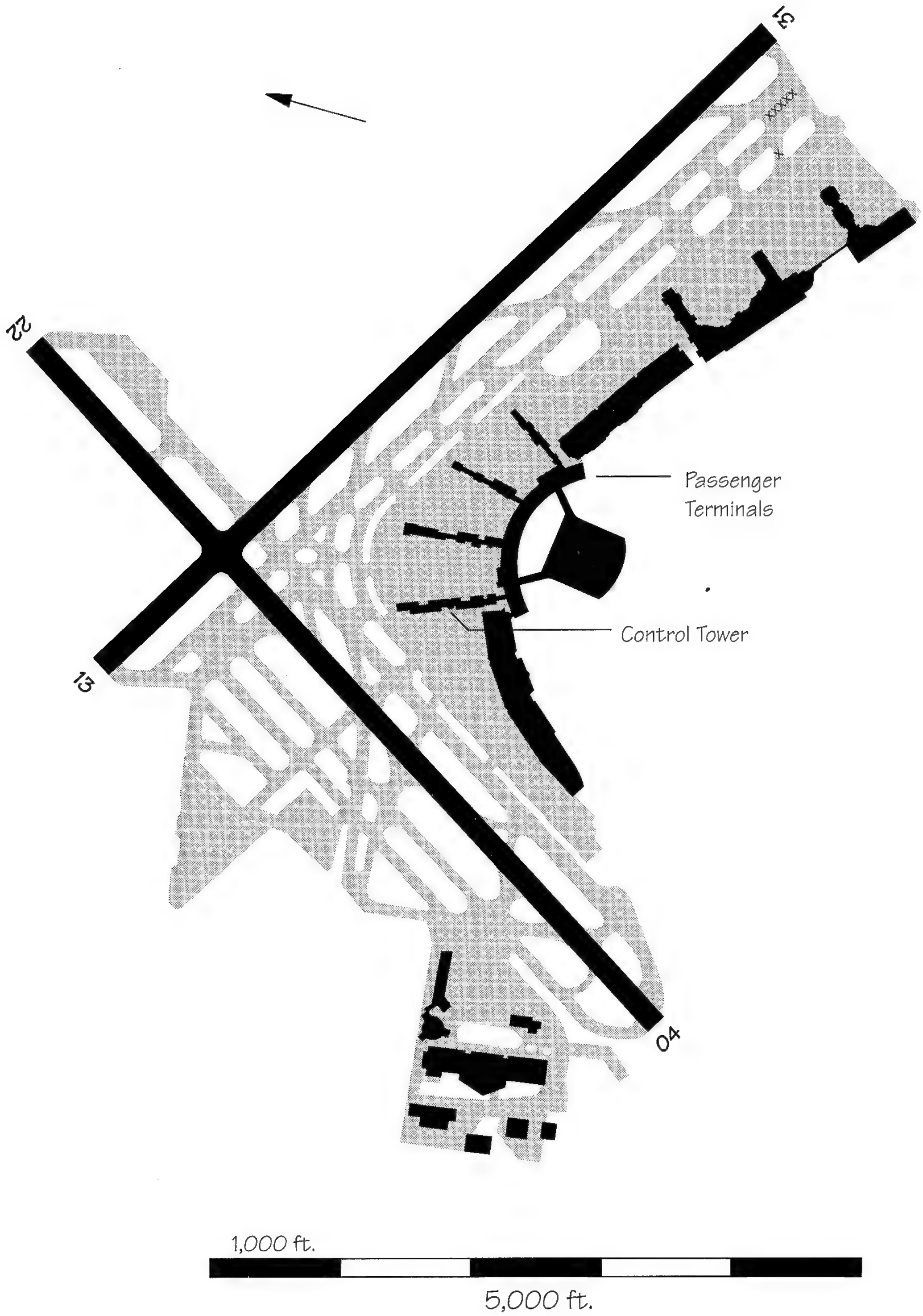
Los Angeles International Airport (LAX)



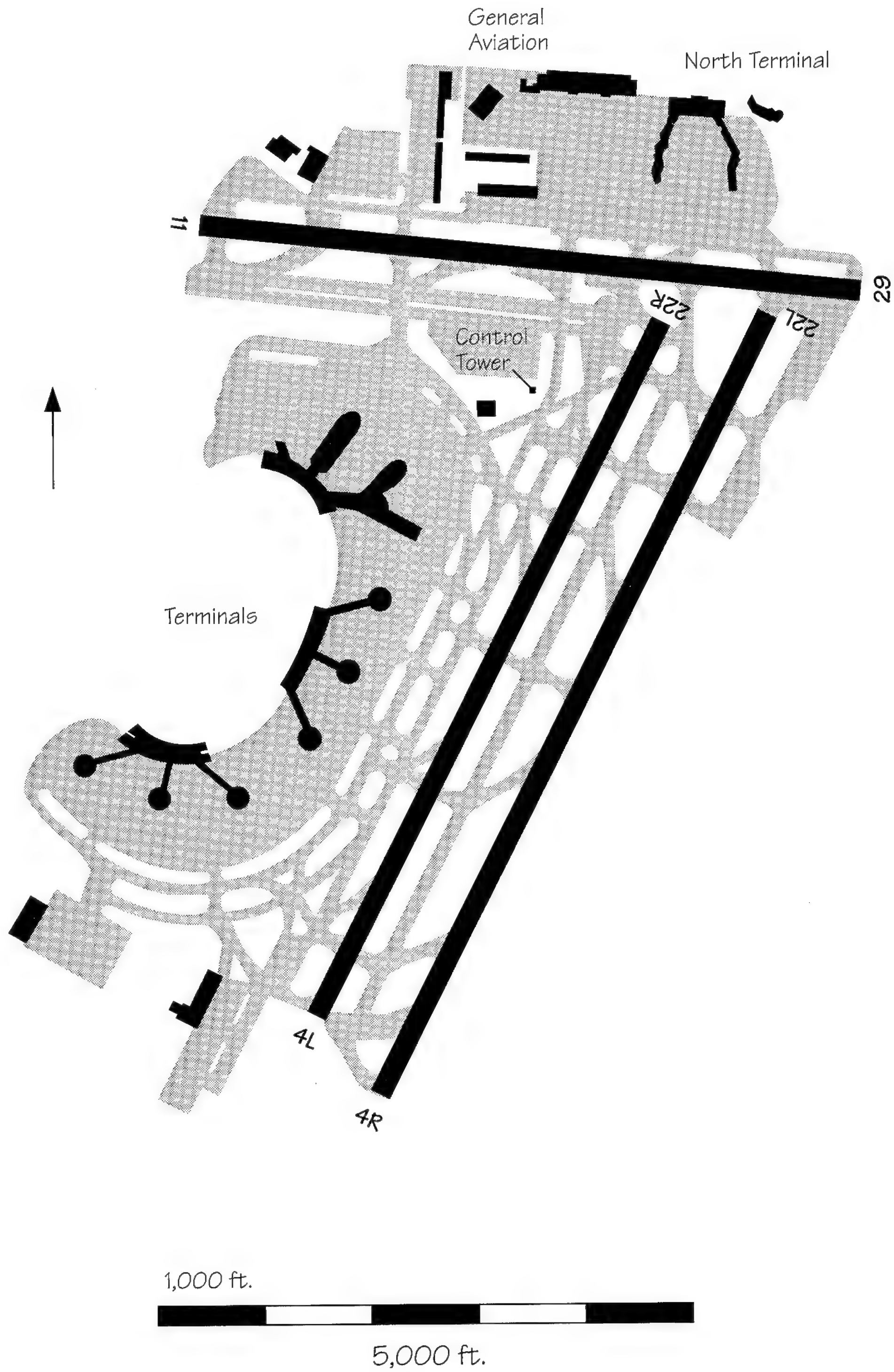
Metropolitan Oakland International Airport (OAK)



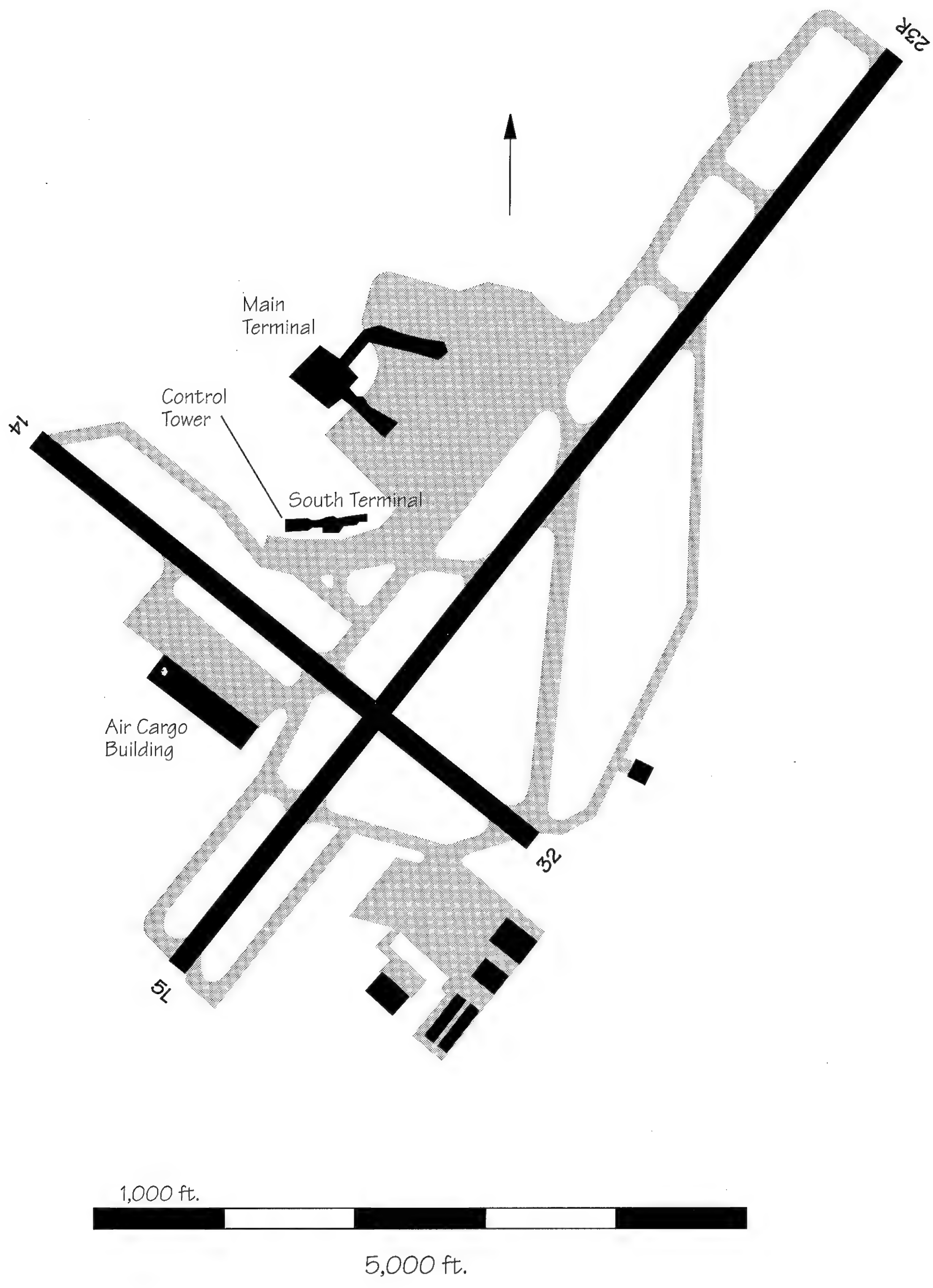
New York John F. Kennedy International Airport (JFK)



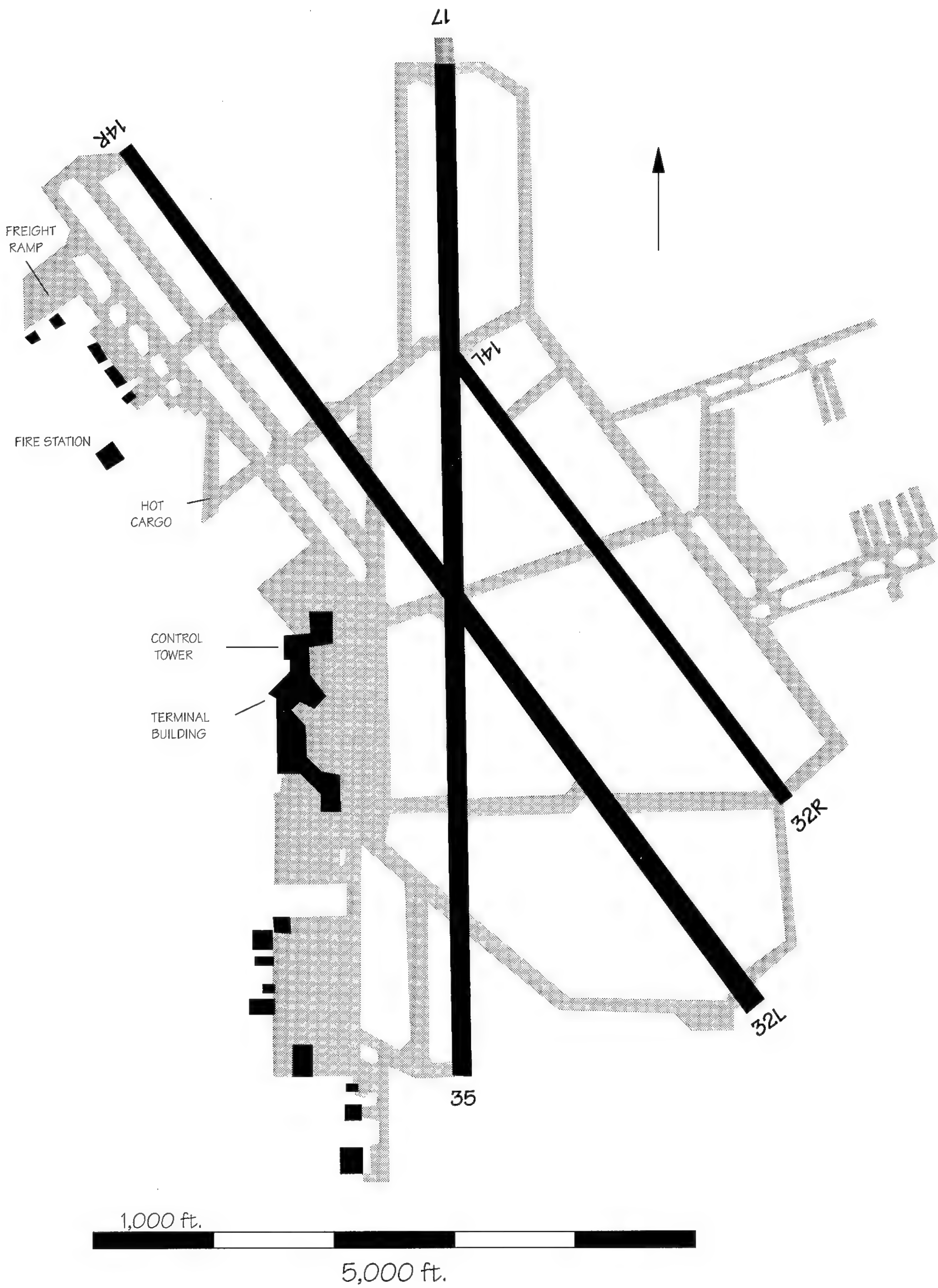
New York LaGuardia Airport (LGA)



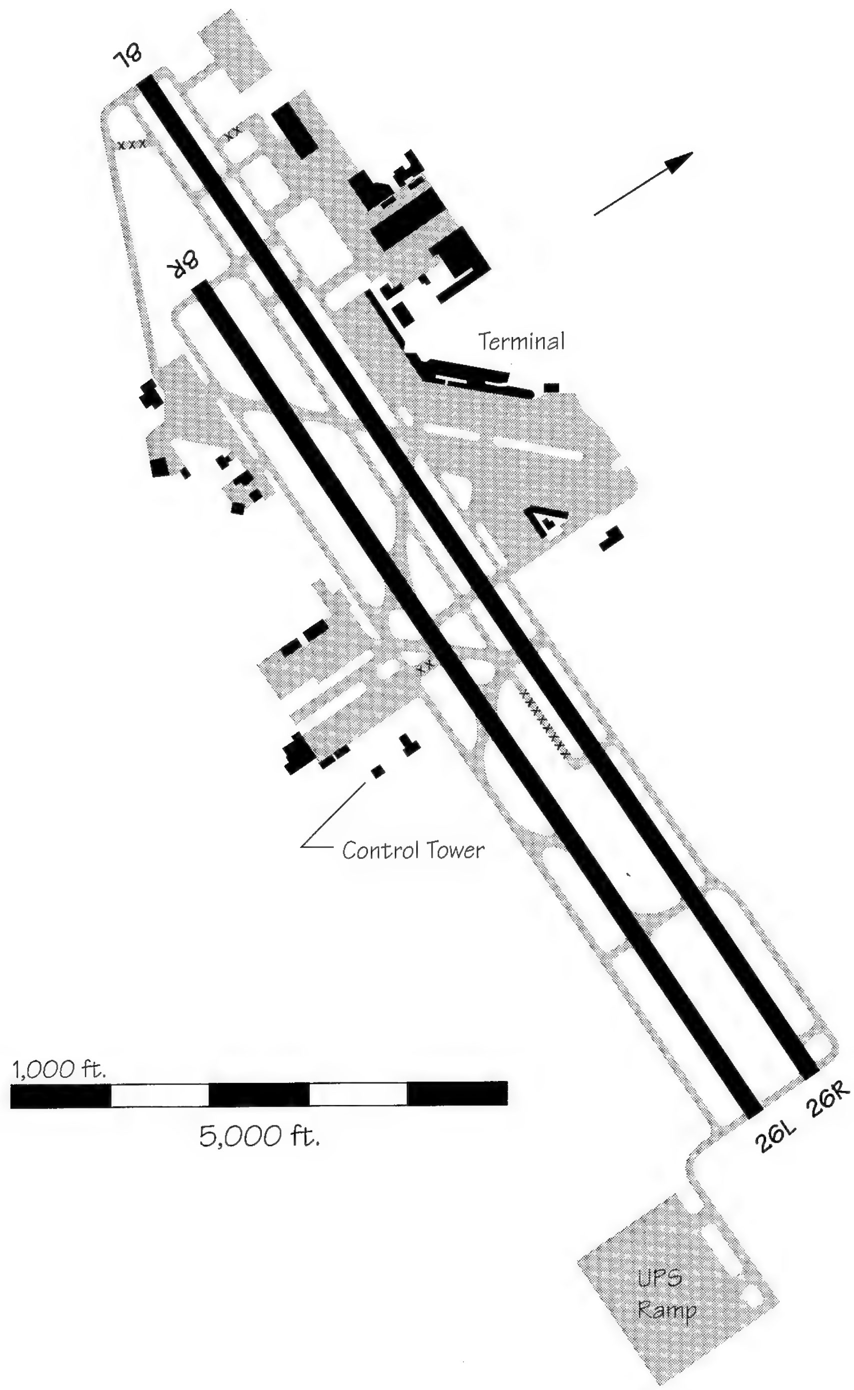
Newark International Airport (EWR)



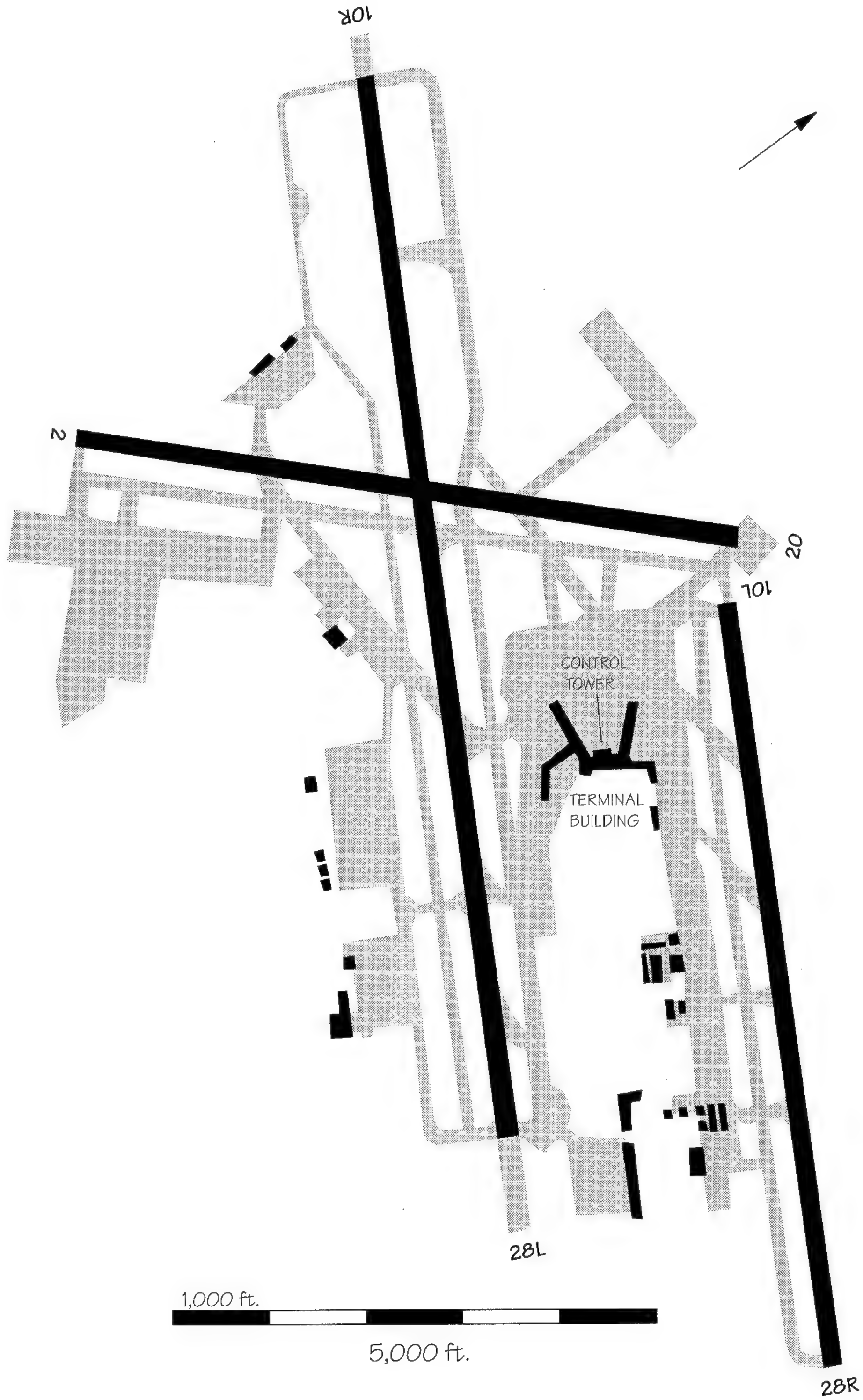
Norfolk International Airport (ORF)



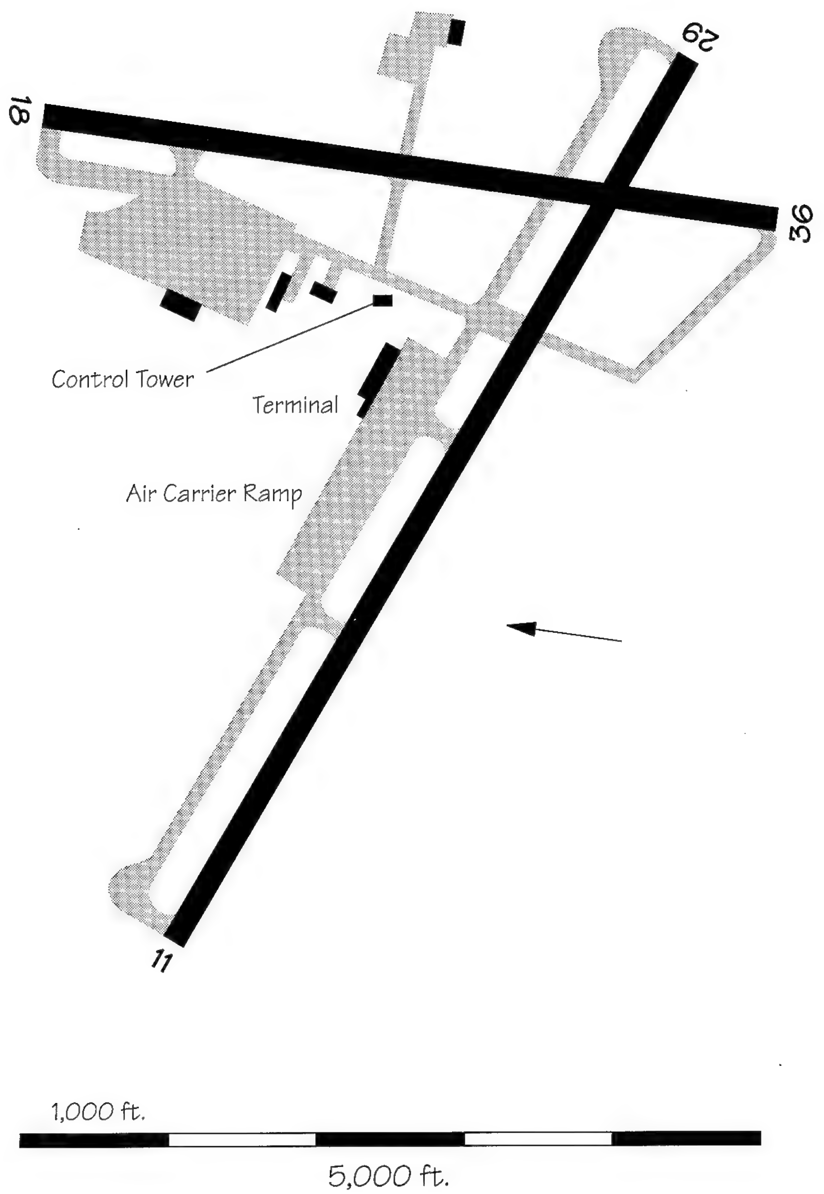
Omaha Eppley Airfield (OMA)



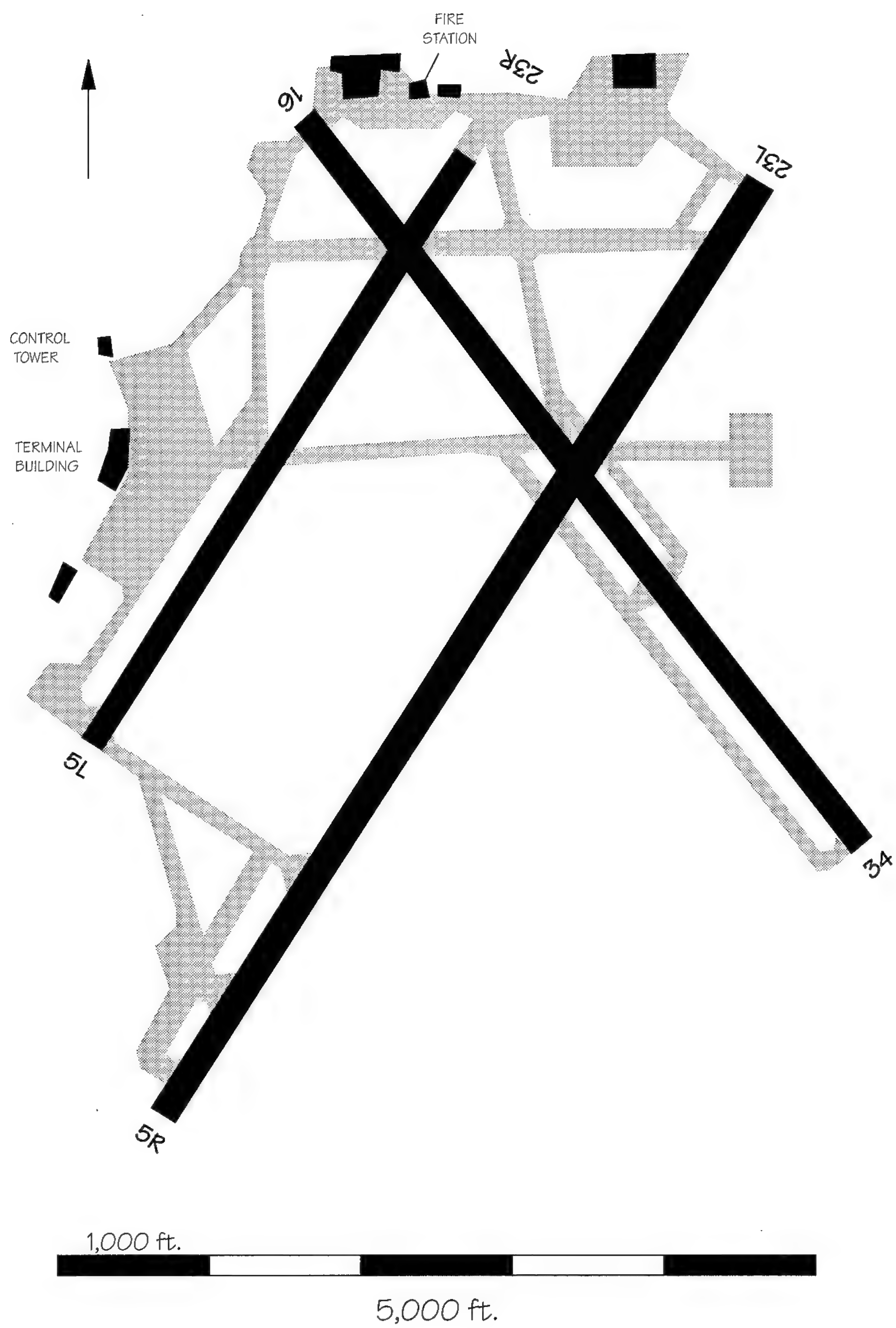
Ontario International Airport (ONT)



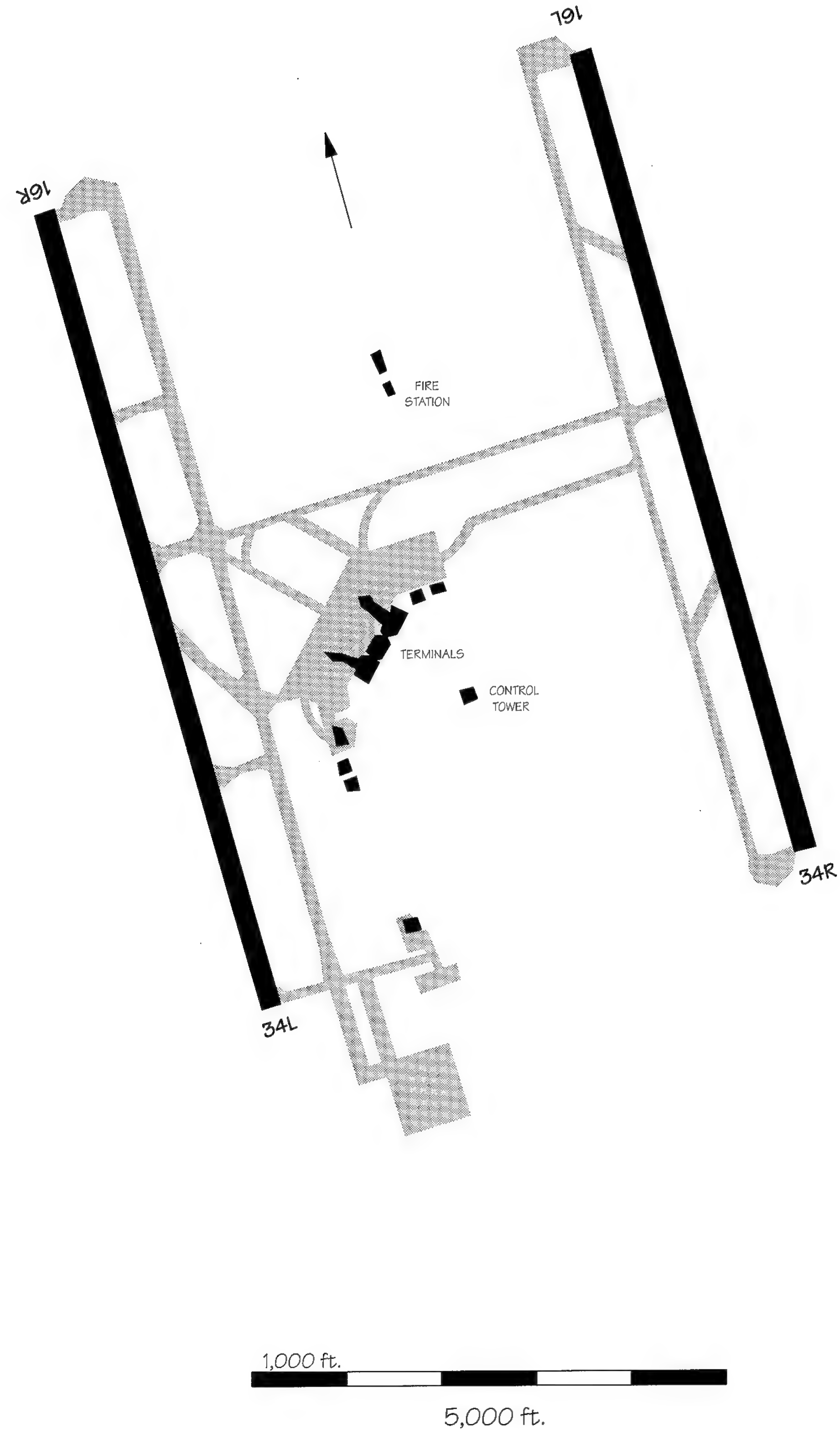
Portland International Airport (PDX)



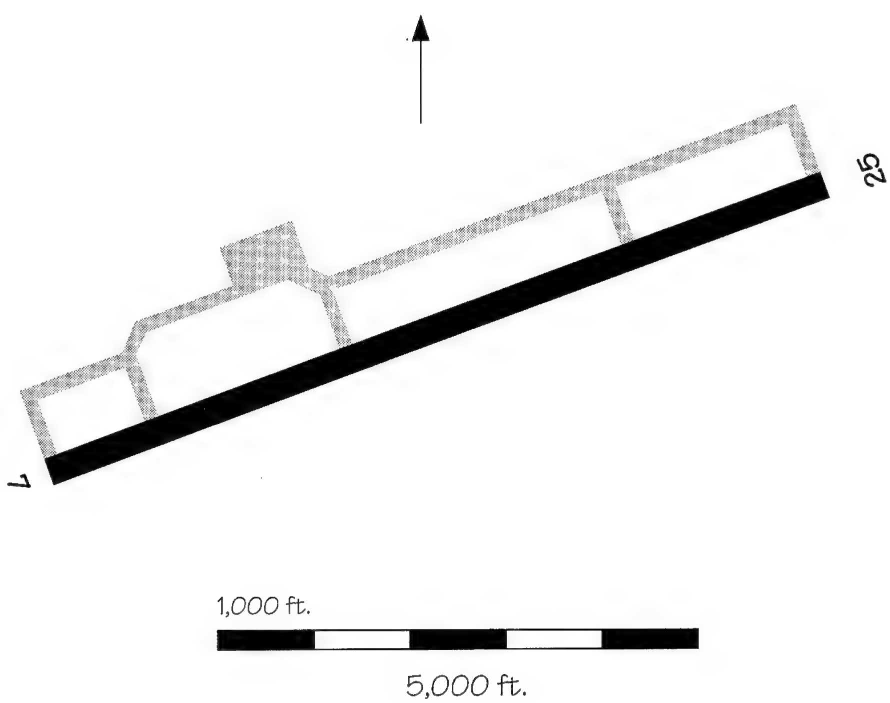
Portland International Jetport (PWM)



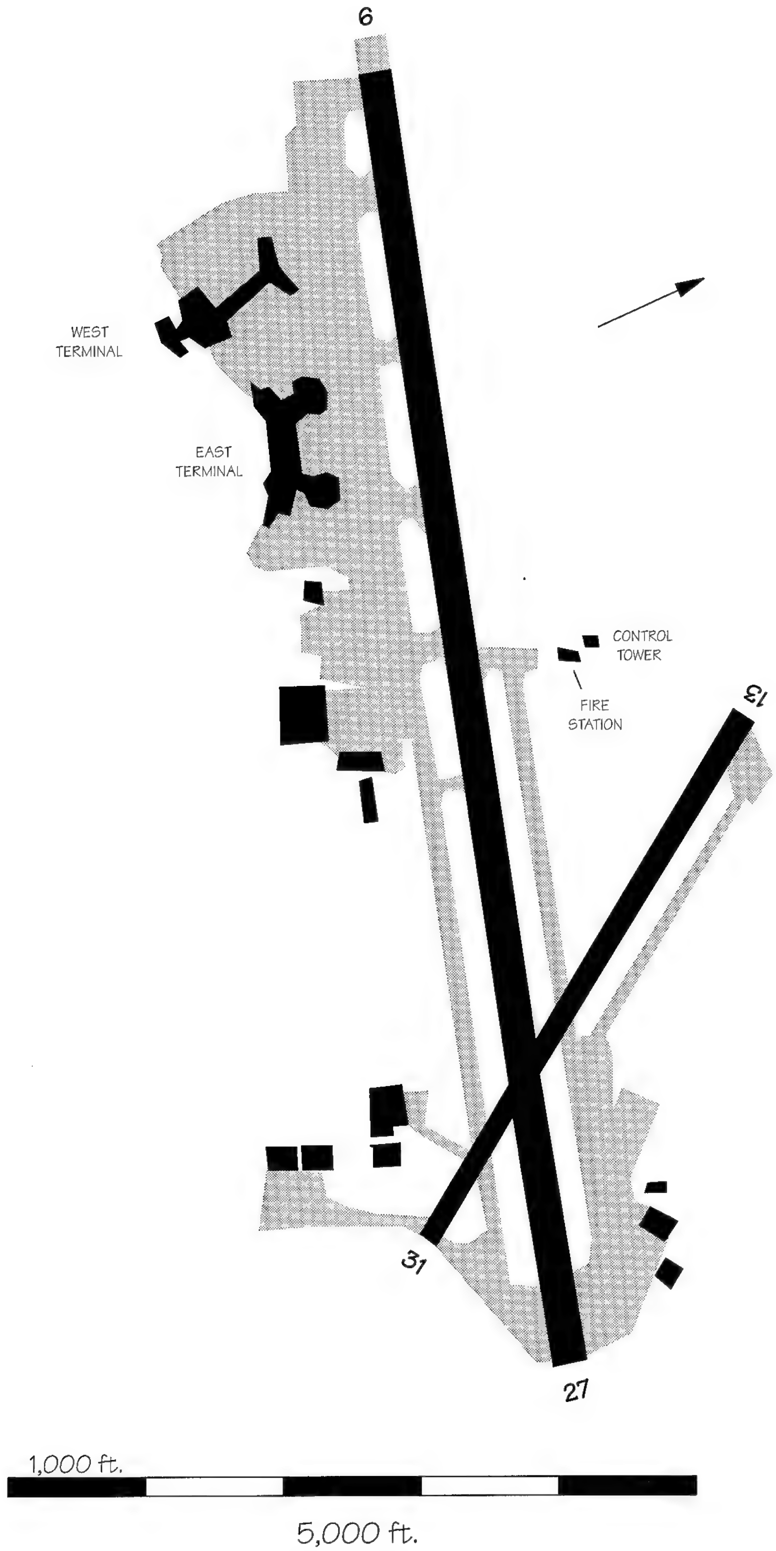
Providence Theodore Francis Green State Airport (PVD)



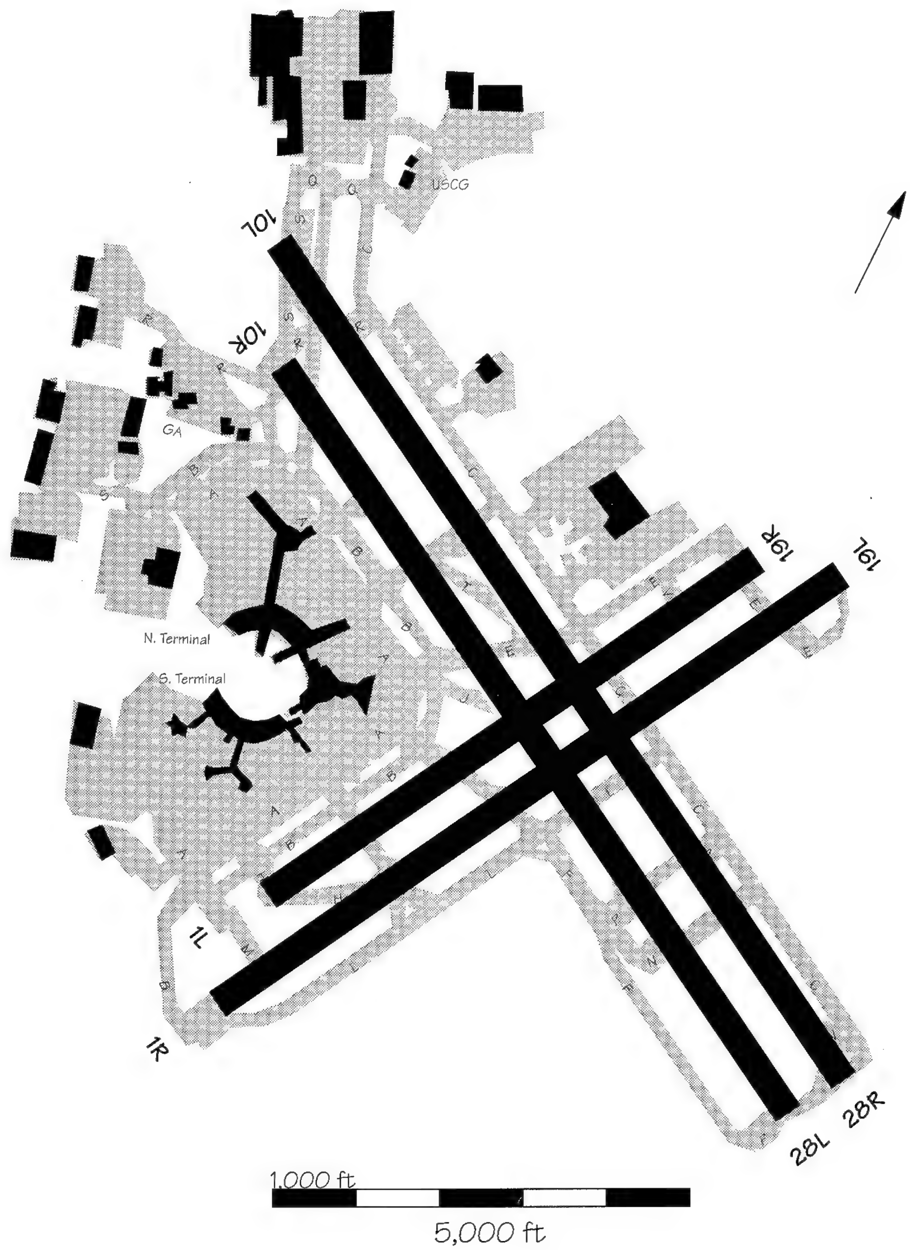
Sacramento Metropolitan Airport (SMF)



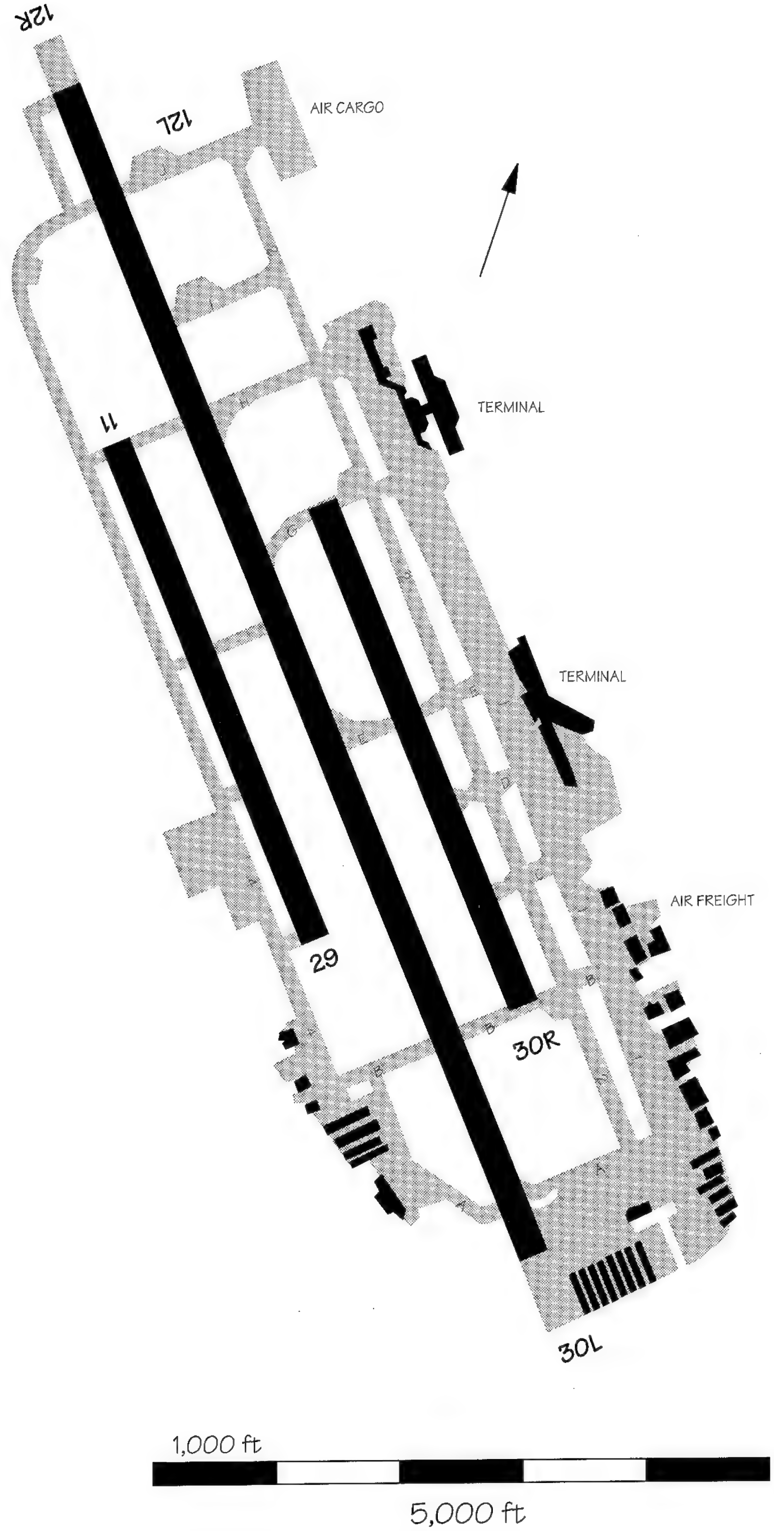
Saipan International (GSN)



San Diego International Lindberg Field (SAN)

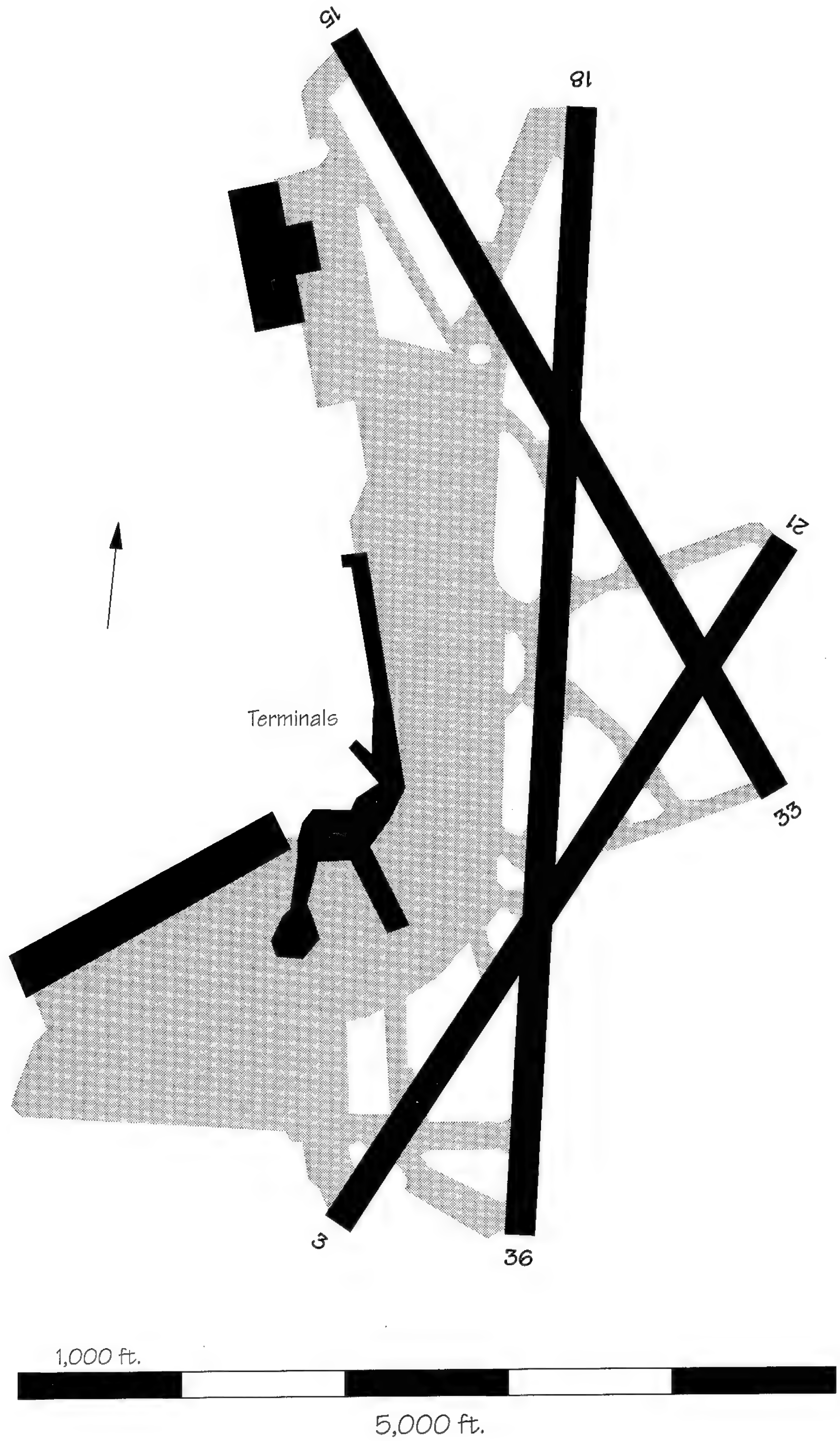


San Francisco International Airport (SFO)

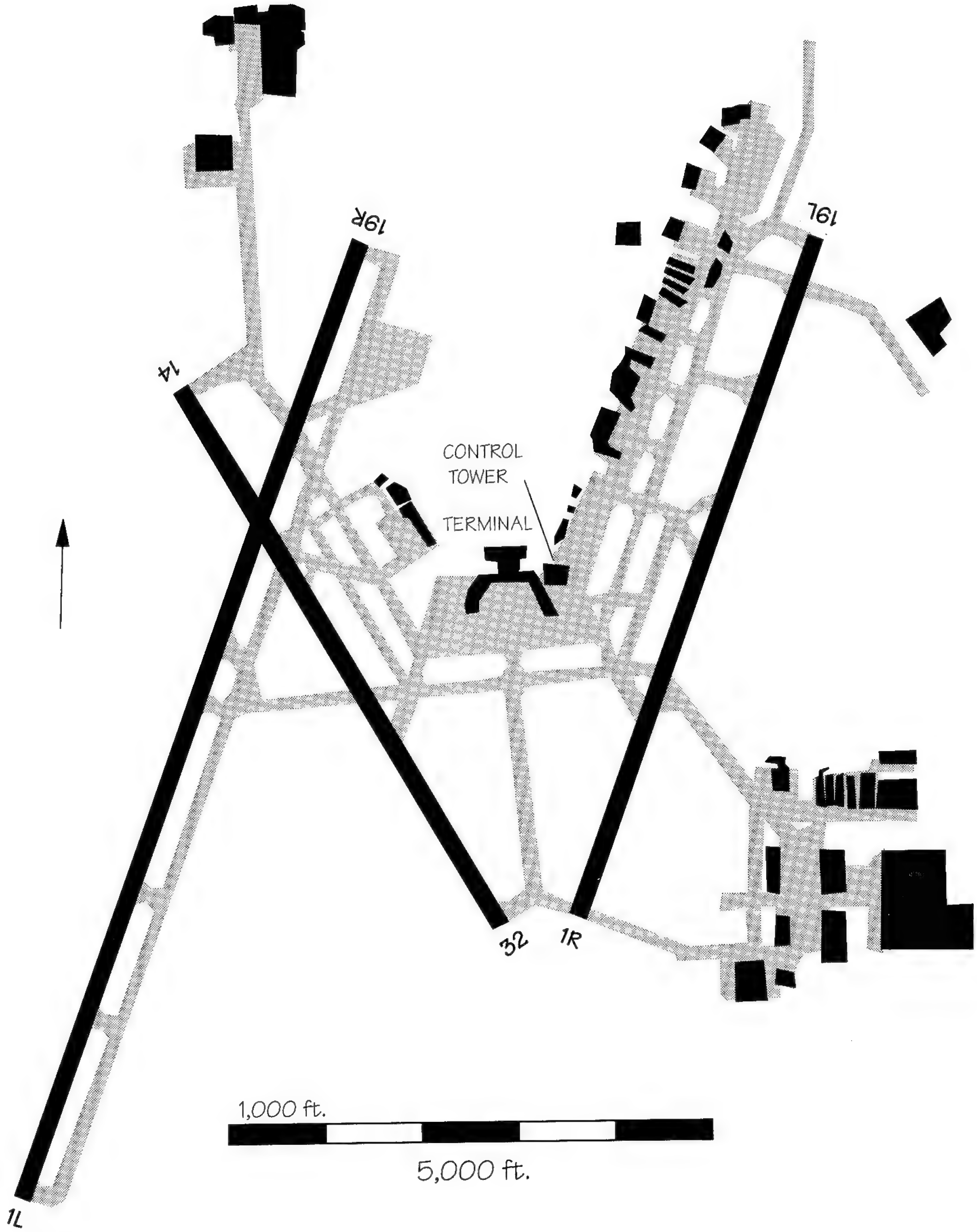


San Jose International Airport (SJC)

San Juan Louis Muñoz Marín International Airport (SJU)



Washington National Airport (DCA)



Wichita Mid-Continent Airport (ICT)

Appendix F

Airport Capacity Design Teams Potential Savings from Recommended Airfield Improvements

This appendix expands on the summary material in Table 2-4. Estimates in savings are in hours of delay and millions of dollars for selected airfield improvements recommended by the various Airport Capacity Design Teams. Estimates are given based upon demand — rated in annual operations — at current levels and future projections, refered to as Baseline, Future 1, and Future 2. Demand levels for each airport varied, and are listed in the tables.

It should be noted that the particular combination of computer models and analytic methods used to calculate the annual delay costs and benefits is unique to each airport. Therefore, it is difficult, if not impossible, to compare one airport with another.

For further details on individual airports and recommendations, refer to Appendix C and the specific Design Team study reports.

Fort Lauderdale-Hollywood International Airport

	Estimated Annual Delay Savings (hours and millions of 1990 dollars)					
	Baseline-219,000		Future 1-294,000		Future 2-350,000	
Recommended Improvement	Hours	$M	Hours	$M	Hours	$M
2d) Extend Runway 9R/27L 10,000 ft. long, 150 ft. wide, with CAT I ILS Project Cost = $259M	1,355	$1.62	7,910	$11.12	20,680	$32.34
4b) Improve angles exits on Runway 27R at Twy F Project Cost = $0.045M	66	$0.08	105	$0.15	124	$0.19

Greater Pittsburgh International Airport

	Estimated Annual Delay Savings (hours and millions of 1990 dollars)					
	Baseline-471,000		Future 1-540,000		Future 2-618,000	
Recommended Improvement	Hours	$M	Hours	$M	Hours	$M
6) Construct south parallel runway 4,300 ft. south of Runway 10R/28L and north parallel runway 1,000 ft north of Runway 10L/28R	—	—	59-60	$67-$68†	124-126	$127-$129†

† The lower value represents Runway 10L use without jet departures; higher value, with jet departures.

Honolulu International Airport

	Estimated Annual Delay Savings (hours and millions of 1991 dollars)					
	Baseline-407,000		Future 1-500,000		Future 2-700,000	
Recommended Improvement	**Hours**	**$M**	**Hours**	**$M**	**Hours**	**$M**
4) Extend Runway 4L/22R to southwest to 10,000 ft. Project Cost = $44.8M	7,290	$14.2	32,920	$64.1	42,420	$82.6
9) Construct Runway 8C/26C Project Cost = $86.0M	13,510	$26.3	57,880	$112.7	382,490	$744.7
12) Construct angles exits on Runways 4R, 8L, and 26L Project Cost = $10.0M	460	$0.9	7,860	$15.3	32,820	$63.9

Houston Intercontinental Airport

	Estimated Annual Delay Savings (hours and millions of 1992 dollars)					
	Baseline334,000		Future 1-450,000		Future 2-650,000	
Recommended Improvement	**Hours**	**$M**	**Hours**	**$M**	**Hours**	**$M**
1a) Extend Runway 14R/32L Project Cost = $13.4M	1,300	$2.2	11,400	$20.0	189,600	$330.0
1f) New Runways 8L/26R and 9R/27L for quadruple independent approaches Project Cost = $135.5M	(11,100)	($13.7)	24,000	$41.7	764,400	$1,335.4
2b) New high speed exit on Runway 14R Project Cost = $0.72M	1,100	$0.6	7,600	$10.4	313,600	$545.7

Los Angeles International Airport

Recommended Improvement	Estimated Annual Delay Savings (hours and millions of 1990 dollars) Baseline-641,751 Hours	$M	Future 1-711,092 Hours	$M	Future 2-782,056 Hours	$M
1) Construct departure pads	7,692	$14.06	30,701	$60.29	67,274	$141.23
5a) Construct 24 remote gates	—	—	—	—	1,722	$3.62
Project Cost = $36.3M						
7) New high speed Taxiway 43	441	$0.8	444	$0.87	455	$0.96
Project Cost = $5.3M						

Minneapolis-Saint Paul International Airport

Recommended Improvement	Estimated Annual Delay Savings (hours and millions of 1992 dollars) Baseline-420,390 Hours	$M	Future 1-530,000 Hours	$M	Future 2-600,000 Hours	$M
4) New Runways 17/35 and 11N/29N	8,438	$12.2	26,296	$38.1	56,548	$81.8
Project Cost = $307.0M						
7) New full-length parallel taxiway for Runway 11R/29L	927	$1.3	1,147	$1.7	2,340	$3.4
Project Cost = $16.0M						
8) Dual crossover taxiways for Runways 11L/29R and 11R/29L	2,084	$3.0	3,294	$4.8	3,787	$5.5
Project Cost = $20.0M						

Nashville International Airport

Recommended Improvement	Baseline-266,000 Hours	Baseline-266,000 $M	Future 1-417,500 Hours	Future 1-417,500 $M	Future 2-534,000 Hours	Future 2-534,000 $M
	Estimated Annual Delay Savings (hours and millions of 1989 dollars)					
1) Relocate Runway 2C and extend to 8,000 ft.	—	—	2,969	$2.9	7,585	$7.6
Project Cost = $33.0M						
4) Improve Taxiways	—	—	413	$0.4	1,034	$1.0
Project Costs = $27.8M						
5b) New Runway 2E/20E 2,500 ft. east of Runway 2R/20L	—	—	4,371	$4.6	7,413	$7.8
Project Cost = $150.0M						
11) Connecting taxiway from Concourse D to Runway 2R/20L	—	—	4,017	$4.0	7,392	$7.5
Project Cost = $15.0M						

Philadelphia International Airport

Recommended Improvement	Baseline-410,000 Hours	Baseline-410,000 $M	Future 1-500,000 Hours	Future 1-500,000 $M	Future 2-565,000 Hours	Future 2-565,000 $M
	Estimated Annual Delay Savings (hours and millions of 1990 dollars)					
2) New 5,000 ft. commuter Runway 8/26	20,402	$28.4	88,171	$122.8	154,624	$215.4
Project Cost = $169.2M						
3) Relocate Runway 9L/27R 400 ft. south				†		
Project Cost = $108.7M						
4) Shift Runway 9L/27R 2,735 ft. to the west				†		
Project Cost = $54.9M						
5) Shift Runway 9R/27L 1,000 ft. to the east				†		
Project Cost = $30.6M						

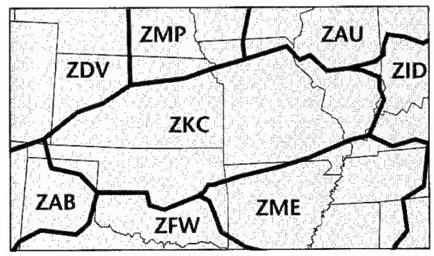
† The savings shown represent the combined benefits of recommended improvements 2, 3, 4, and 5.

Appendix G

Airspace Capacity Design Studies

Studies completed to date are summarized in this appendix. It should be noted that these studies only considered the technical and operational feasibility of the proposed alternatives. Environmental, socioeconomic, and political issues will be addressed in future planning studies.

G.1 Kansas City Area Airspace Project[1,2,3]



The purpose of the Kansas City Airspace Capacity Project was to evaluate proposed operational alternatives in the St. Louis and Kansas City TRACONs and Kansas City ARTCC airspaces. The Kansas City Airspace Capacity Project consisted of three simulation analyses. Results of each were analyzed with respect to increasing capacity, reducing delay, and improving efficiency.

G.1.1 St. Louis TRACON Operational Alternatives

The first simulation analysis considered delay and capacity impacts at Lambert-St. Louis International Airport (STL) associated with relocating arrival fixes based on a four cornerpost VOR concept, implementing dual arrival routes over the cornerposts, and developing new departure routes.

Two options for the St. Louis TRACON were studied. The first alternative considered a dual arrival route system with no other modifications to the existing TRACON or Kansas City ARTCC airspace and traffic systems.

The second alternative considered a four cornerpost VOR system, relocating arrival fixes, providing dual arrival routes, adding new departure gates for St. Louis TRACON, and making significant Kansas City ARTCC routing changes. Greater delay

1. Kansas City Airspace Capacity Project, May 1991
2. Lambert-St. Louis International Airport Capacity Enhancement Plan, June 1988
3. Kansas City International Airport Capacity Enhancement Plan, September 1990

savings were realized from the second alternative than from the first as a result of the proposed airspace changes. These proposed changes reduce restrictions on aircraft flowing through the arrival fixes and increase the number of departure routes available, thus making use of previously unused runway capacity at STL due to increased airspace capacity in the St. Louis TRACON.

A recommendation of the study was that runway capacity expansion at STL should be considered if the potential benefits of a new airspace network are to be realized during IFR conditions.

The Lambert-St. Louis International Airport Capacity Enhancement Plan, completed in 1988, addressed this issue. The goals of the study were to increase IFR capacity at the airport to equal VFR capacity. The recommendations of the St. Louis Task Force Study are listed in Appendix C.

Recommendations for St. Louis designed for airfield improvement included: constructing a new runway parallel to Runway 12L/30R, constructing angled exits on Runway 12L/30R, and constructing three major taxiway extensions parallel to Runway pairs 12R/30L and 12L/30R and Runway 6/24.

Facility and equipment improvements recommended included: installing a CAT III ILS system on Runways 12L and 30R, installing a precision approach system on Runway 6 to lower landing minimums on Runway 6 and also to support approaches during IFR weather conditions to Runways 30R and 30L, and installing runway alignment indicator lights (RAILs) and centerline lights on Run-way 24 to lower approach minimums and support converging approaches during IFR to Runways 24, 30L, and 30R.

G.1.2 Kansas City TRACON Operational Alternatives

The second simulation analysis evaluated proposed airport/airspace improvements designed to increase capacity at Kansas City International Airport (MCI). This analysis considered three alternatives. The first alternative added a new north/south parallel runway at MCI. The second alternative analyzed a four cornerpost VOR system, relocated arrival fixes, and provided dual arrival routes for MCI. The third alternative included the four cornerpost VOR system, relocated the arrival fixes, added dual arrival routes, and added a new north/south parallel runway at MCI.

Simulation results of the second alternative showed that there would be daily savings in delay gained by using the proposed four cornerpost VOR system. The delay savings, though, are only realized during VFR weather conditions.

The third alternative resulted in added delay savings for both VFR and IFR weather conditions. The capacity increases afforded by dual runways and dual arrival routes significantly increased airfield capacity, especially at the 200 percent traffic demand level.

Runway capacity expansion at Kansas City International Airport is to be strongly considered and was a major objective of the Kansas City Capacity Design Team in its report of September 1990. Recommendations that directly relate to increasing runway capacity under IFR weather conditions are listed in Appendix C.

Recommendations for Kansas City designed for airfield improvement included: independent 9,500 foot parallel Runway 1R/19L, independent 10,000 foot parallel Runway 18R/36L, high speed exits for Runways 1L and 19R, and high speed exits for Runway 27R.

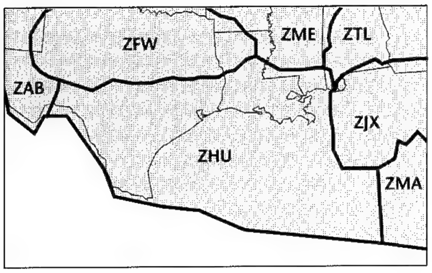
Facility and equipment improvements recommended included: installing a CAT III ILS for Runway 1R, installing a CAT I ILS for Runway 19L to allow for simultaneous approaches to Runways 19L and 19R, installing an ILS/MLS for Runway 27R to provide precision approaches and allow for simultaneous converging approaches to Runway 27R and north/south runways in IFR without the application of visual separation, and upgrading Runway 1L ILS to CAT III.

G.1.3 Kansas City En Route Airspace Alternatives

The third simulation analyzed modifications of Kansas City ARTCC traffic flows to align with the St. Louis and Kansas City TRACON arrival and departure changes made in the first two simulations, rerouted overflight traffic based on specific destination criteria, and raised the ceiling on low altitude sectors from FL230 to FL270.

Simulation results show that raising the low altitude ceilings to FL270 would provide immediate delay savings at the baseline demand level and as overflight traffic increases within Kansas City ARTCC. Higher ceilings for low altitude sectors should provide a more balanced distribution of traffic by sector.

G.2 Houston/Austin Airspace Project[4]



The purpose of the Houston/Austin Airspace Capacity Project was to support the FAA Southwest Region in their planning efforts and quantitatively evaluate the impacts of proposed operational alternatives in the Houston and Fort Worth Air Route Traffic Control Centers (ARTCCs), terminal airspace operations in the Austin Terminal Radar Approach Control (TRACON), and airfield operations at the existing Robert Mueller Airport and at the proposed new Manor Airport in Austin.

The Austin TRACON provides air traffic control services in the terminal airspace surrounding Robert Mueller Airport. Austin TRACON airspace has Robert Mueller Airport located near the center and Bergstrom Air Force Base located southeast of Robert Mueller Airport. In addition to Robert Mueller Airport, the primary airport, there are 11 satellite airports within the Austin TRACON.

Two simulation analyses were conducted to quantitatively evaluate the capacity and delay impacts of operational alternatives in the Houston and Fort Worth Centers and in the Austin TRACON. The first involved evaluating the capacity gains and delay reductions that would result from construction of the new airport at Manor, Texas, including redesigning airspace structures, routings, and procedures in the Austin TRACON. The second simulation analysis involved analyzing the impacts of potential rerouting of specific Austin-bound traffic from the east coast through the Fort Worth Center instead of via the present routing through the Houston Center.

G.2.1 New Austin Airport/Airspace System

The runway system for the existing Austin Municipal Airport, Robert Mueller Airport, consists of three runways: two parallel diagonal runways and a north/south runway. The existing airspace system uses a combination of radar vectors and preferential arrival routes for arriving aircraft bound for airports within the Austin terminal area. In addition, an approach is available for Bergstrom AFB high performance jet arrivals. Aircraft depart the Austin TRACON airspace via radar vectors, preferential departure routes, or the jet airway structure.

4. Houston/Austin Airspace Capacity Project, May 1991

The proposed system incorporates several major airspace and procedural modifications. The new airport will be located near the town of Manor, which is approximately 11 miles northeast of Mueller Airport, around which the existing airspace and procedures were designed. The new proposed Manor Airport consists of two parallel air carrier runways, spaced 5,800 feet apart. The spacing between the two runways allows simultaneous independent IFR approaches. In order to accommodate the new airport's traffic patterns and extended final approach courses, Austin TRACON airspace will be expanded 5 miles northward and eastward to a point approximately 35 miles east of the Manor Airport.

A modified four cornerpost system is proposed for arrivals, providing for segregated traffic, both vertically and laterally separated on parallel arrival routes from three directions. The departure route design is based on major traffic flows allowing for segregation by destination. The plan allows for multiple departure routes diverging at or near the airport resulting in an increased departure capacity. With about 70 percent of Bergstrom Air Force Base traffic operating to the west, a separate departure route dedicated to military operations was created, thereby segregating very high performance aircraft from other types.

Traffic demand schedules were generated for two scenarios. The first projected traffic growth without the development of an airline hub at the new Manor Airport, and the second scenario projected traffic growth with the development of an airline hub. Each scenario assumed little or no change in general aviation and military operations, moderate growth in commuter operations, and significant growth in air carrier operations.

Weather conditions strongly influence the capacity at Mueller Airport due to impacts on runway utilization and dependencies, procedures, and separation criteria. Under IFR, capacity decreases at both the existing and proposed airports primarily because arriving aircraft must conduct instrument approaches, thus increasing separation requirements for arriving aircraft and between successive departure operations. At the existing airport, decreases result due to the inability to run simultaneous approaches to the closely-spaced parallel runways and to the dependency of departure operations from the two runways. In addition, converging approaches at the existing airport are impractical. At the new proposed Manor Airport, on the other hand, the runways are spaced far enough apart that there is no dependency between departure operations, and criteria for simultaneous ILS approaches are met, resulting in a higher capacity operation than that at the existing airport.

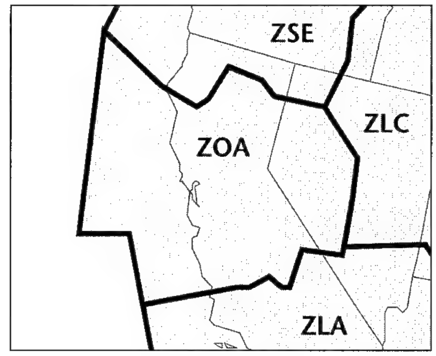
Simulation results indicate that airspace restructuring and the construction of a new airport at Austin with two new independent air carrier runways would result in significant increased capacity and cost savings when compared to the existing airfield and airspace structure. Delay and cost savings would be realized for both the hub and non-hub projections in traffic growth.

G.2.2 East Coast Traffic Rerouting Option

The second simulation analysis evaluated proposed rerouting of specific Austin-bound East Coast traffic. East Coast jet traffic arriving at Austin from the direction of Atlanta, Georgia, is currently routed entirely through Houston Center. An alternative route under consideration involves routing the traffic through Fort Worth Center at high altitude with the jet traffic bound for the DFW area. The flights bound for Austin would descend southwest bound to enter Houston Center south of the Waco VORTAC, in-trail with other Austin arrivals from the DFW area. Air traffic operations in the Houston and Fort Worth Centers for three demand levels under VFR were simulated. The new Austin airport/airspace system was assumed to be in place, with an airline hub serving the East Coast established at Manor Airport, by the second traffic demand level.

Simulation results for the hub scenario traffic demand levels provided results for assessing the delay impact of the routing alternatives. The overall system-wide delay associated with routing the east coast traffic through Houston Center was compared with the corresponding delay associated with routing the traffic through Fort Worth Center. Simulation results indicate that flights incur less travel time when routed via the present route through Houston Center instead of the alternative route through Fort Worth Center.

G.3 Oakland Airspace Project[5,6]



The purpose of the Oakland Center Airspace Analysis Project was to evaluate the delay and capacity impacts of proposed operational alternatives aimed at increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations within the Oakland Air Route Traffic Control Center (ARTCC), terminal airspace operations in the Bay and Sacramento Terminal Radar Approach Controls (TRACONs), and airfield operations at San Francisco International (SFO), Metropolitan Oakland International (OAK), San Jose International (SJC), and Sacramento Metropolitan (SMF) Airports.

The Oakland Air Route Traffic Control Center (ARTCC) adjoins three other domestic ARTCCs and has an oceanic control area to the west, which provides air traffic services to transpacific flights. Air traffic operations within Oakland Center airspace are very complex. There exists a significant east to west and north to south traffic flow, several interactive, high density airports, considerable military activity, and numerous geographical constraints restricting radar coverage, radio communications, and air traffic movement. Traffic handled by the Oakland Center includes overflights, arrivals, departures, and intra-center traffic. Due to its geographical location, the majority of flights within the Oakland ARTCC are either climbing or descending. The three Bay Area airports account for over 55 percent of the total Oakland Center IFR operations.

The Oakland Center Airspace Analysis Project consisted of four major simulation analysis tasks. Results of each were analyzed with respect to increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations and are summarized below.

G.3.1 Sector 11 Initiative

The first simulation analysis task involved evaluating two proposed airspace realignment and routing alternatives to alleviate complexity and saturation problems associated with Oakland Center Sector 11.

5. Oakland Center Airspace Analysis Project, June 1991
6. San Francisco Bay Area Airport Task Force Capacity Study of SFO, SJC, and OAK International Airports, December 1987

Sector 11 is one of 25 en route sectors located within the Oakland Center. The base of Sector 11 airspace commences at the surface and attains its highest altitude at FL230. Some shelving exists at the lower altitudes, mainly where Sector 11 interfaces with Bay TRACON, Monterey Approach Control, and Stockton Approach Control. Sector 11 is a relatively small sector, encompassing the majority of the area south of San Jose International Airport, approximately 45 miles north to south and 60 miles east to west.

Alternative A involved an extension of the lateral and vertical confines of Bay TRACON, Monterey Approach Control, and Stockton Approach Control; a modification to the major San Jose International Airport jet arrival routes to conform with proposed boundary and procedure changes between Bay TRACON and Oakland ARTCC Sector 11; and a reduction in metering restrictions to San Jose International Airport from the Los Angeles Basin and southwestern U.S. Alternative B included the changes proposed in Alternative A, plus it extended the ceilings of Monterey and Stockton Approach Controls.

Both improvement options proposed under the Oakland Sector 11 Initiative result in capacity gains and delay savings, though Alternative B results in greater delay savings when compared to baseline operations. This is due to fewer aircraft impacting Oakland Center Sector 11 and reduced in-trail separation standards required within approach control airspace. Besides the operating cost savings realized under the Sector 11 improvement alternatives, additional benefits would include: reduced Sector 11 complexity and traffic density; increased sequencing flexibility for Bay TRACON to merge traffic; reduced en route traffic metering; reduced inter-facility and intra-facility coordination; and a more efficient airspace alignment, resulting in an increased capacity to handle future traffic demand with reduced delay.

There is a narrowing of the margin between the delay and cost savings benefits between the alternatives in future demand levels when compared to the baseline and to each other due to limited runway capacity at San Jose International Airport. Future runway capacity expansion at San Jose International Airport should be a serious consideration if the potential benefits of any new airspace network are to be fully realized for increased traffic demands and IFR conditions.

The San Francisco Bay Area Airports Capacity Task Force's major objective, in its report of December 1987, was to develop an action plan to increase capacity and efficiency and to reduce

aircraft delays at the three Bay Area international airports. Recommendations for San Jose designed to maximize the benefits of redesigned airspace include: creating staging areas at Runways 30L and 30R, extending and upgrading Runways 30R and 29, creating angled exits for Runway 12R, promoting use of reliever ILS training facilities, installing MLS on Runway 30L, and implementing simultaneous departures with Moffett Field.

G.3.2 Northern California Combined Radar Facility (NORCAL CRF) Airspace Redesign

The second task in this analysis involved analyzing the system capacity and air traffic delay impacts associated with combining several approach control facilities and delegating airspace from Oakland ARTCC to form the proposed Northern California Combined Radar Facility (NORCAL CRF). The proposed operational changes required: combining Bay TRACON, Travis RAPCON, Sacramento Approach Control, Stockton Approach Control, and portions of Oakland ARTCC into a single radar approach control facility; expanding Monterey Approach Control's area of jurisdiction; developing new sectors and modifying existing sectors within all facilities to conform with the proposed airspace changes; extending Runway 30R at San Jose International Airport to 7,460 feet for specific improvement options; and modifying arrival and departure routes to coincide with the proposed airspace changes. Results were analyzed for VFR and IFR conditions.

Simulation results show that the consolidation of facilities to establish the NORCAL CRF would result in capacity gains, delay savings, and aircraft operating cost savings. Potential benefits associated with establishing the NORCAL CRF facility include: increased sequencing flexibility to merge traffic using terminal in-trail separation criteria; expansion of available TRACON airspace for vectoring of arrival and departure traffic; improved efficiency in merging traffic with Oakland Center; reduced inter- and intra-facility coordination, and a more efficient airspace alignment resulting in increased capacity to handle future traffic demands with reduced delay. The extension of Runway 30R at San Jose International Airport would provide increased capacity to more efficiently accommodate current traffic demand as well as future traffic growth at the airport. Extending Runway 30R at San Jose International Airport in conjunction with implementing the NORCAL CRF airspace redesign produces even greater delay savings and cost

benefits than separately adding together the delay benefits and cost savings of each option.

G.3.3 Sacramento Airspace Routings Analysis

The third simulation analysis task involved evaluating alternative routings and procedures proposed to alleviate noise problems in the Sacramento Metropolitan area. Analyses were performed to determine the impact that these routings might have on current traffic flows within the Sacramento TRACON and Oakland Center. Four routing options were analyzed (one northwind and three southwind operations); a combination of the northwind alternative with each of the southwind alternatives was also analyzed.

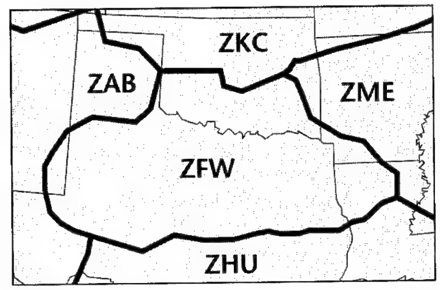
Simulation results show that the four alternative options do not yield any significant arrival delay changes for the baseline traffic demand at Sacramento Metropolitan Airport.

G.3.4 Fallon Special Use Airspace Impact Analysis

The fourth simulation analyzed the capacity and delay impacts associated with rerouting specific traffic to evaluate a proposed reconfiguration of the Fallon Range Training Complex. The proposed operational changes included raising the ceiling on the Fallon area and rerouting civilian traffic currently overflying the Fallon military airspace onto existing routes that circumvent the Fallon training area.

The expansion of the Fallon Range Training Complex significantly reduces Sector 43's airspace previously available for the vectoring of traffic to relieve congestion. The proposed expansion of the Fallon Range Training Complex is situated on a major west to east air traffic corridor. Requiring traffic to be rerouted around or clear of the proposed Fallon Range Training Complex restricts the majority of the departure traffic to using two primary departure routes. This rerouting of traffic results in increased ground delay at impacted airports due to the necessity to provide in-trail separation on airway specific routes instead of utilizing vectors and/or direct routes to expedite traffic movement.

G.4 Dallas-Fort Worth Metroplex Project[7]



The objective of the Dallas-Ft. Worth (DFW) Metroplex Air Traffic Analysis Project was to address a variety of capacity and delay problems and issues in the Dallas/Ft. Worth area, including development of plans for increasing airport and airspace capacity.

This project focused on three primary areas: (1) evaluation of the new airspace design for the DFW area, (2) assessment of the need for and alternatives for providing and utilizing new runway capacity at DFW Airport, and (3) evaluation of the capacity and delay impacts of airspace interactions among traffic from various airports in the DFW area.

These analyses relating to the new DFW airspace were aimed at evaluating and refining routings and procedures for the new airspace design, analyzing the capacity of the new airspace design to accommodate future traffic volumes and expanded airport capacity, and assessing the capability of the new airspace to support procedures for four simultaneous ILS approaches to DFW Airport. Analyses relating to the new runway capacity at DFW Airport were aimed at analyzing new runway alternatives in terms of the type of runway (commuter or air carrier), timing of construction, location on the airfield, use configurations, and operating procedures. Airspace interaction problems analyzed included the interaction between departures from Dallas Love Field and DFW Airport under both North Flow and South Flow operations, and the interactions between DFW Airport arrivals and Navy Dallas Airfield departures and arrivals during North Flow operations.

G.4.1 New Airspace Design for the DFW Area

Simulation analyses were conducted to analyze the capacity of the new DFW airspace system being designed by the DFW Metroplex Program Office of the FAA's Southwest Region. Major modifications to the old system include: expand TRACON airspace from 30 nm to 40 nm by relocating cornerposts and adding two new VORTACs, establish dual jet routing for arrivals over each cornerpost, establish additional

7. The Dallas/Ft. Worth Metroplex Air Traffic Analysis Project, November 1989

terminal departure routings, segregate jet, turboprop, and prop traffic, segregate some military flights from civilian traffic, revise nominal radar vector paths within the TRACON, and revise arrival and departure routings in the Fort Worth Center.

Simulation results show that the maximum benefits from the new airspace design will be realized in the future, with expected airport capacity improvements and increased demand levels, but the airspace design will also yield significant delay reductions and cost savings under current demand levels with existing airport facilities. Furthermore, the simulation results verify that the new airspace system provides the capacity to efficiently accommodate the increased traffic levels forecast through year 2010, including traffic associated with two new air carrier runways at DFW Airport. The new airspace structures and procedures provide the throughput to feed four simultaneous ILS approaches to DFW Airport.

G.4.2 New Runway Capacity at DFW Airport

The simulation of increased levels of traffic clearly indicate that existing runway facilities at DFW Airport do not provide adequate capacity to accommodate forecast traffic demand in the upcoming decade. Without new runway capacity, delays will increase to levels that result in severe economic penalties to aircraft operators and will be too expensive to support planned operations.

Potential airfield improvements at DFW Airport included north extensions on each of the north/south runways on either side of the terminal area with departure staging areas, a new eastside runway with associated taxiways, a new westside runway with associated new taxiways, new terminal facilities, and relocation of the general aviation parking area. The changes that were assumed to be in place depended on the demand year and runway options under consideration in the various simulation runs.

The results from the simulation runs indicated that to maintain the baseline (1987) level of service at DFW Airport (i.e., without increasing flight delays), a new commuter runway will be needed in 1990, a new air carrier runway in the mid 1990's, a new commuter runway and a new air carrier runway around 2000, and two new air carrier runways around the year 2005. In addition, the operational benefits that can be realized by a new north/south air carrier runway on the westside of DFW Airport depends on its location relative to the existing westside diagonal runway. The two options for locating a new westside

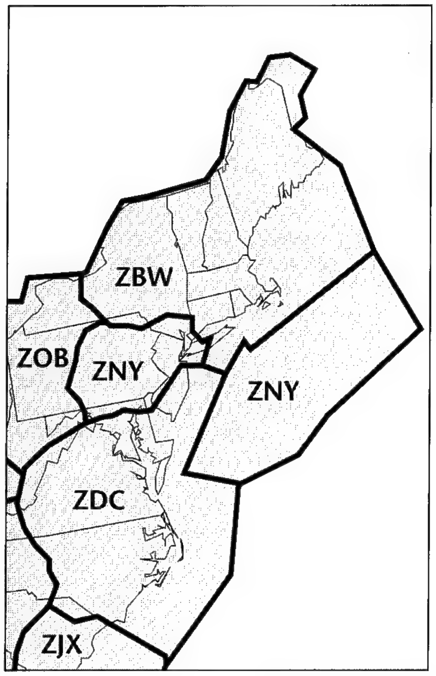
air carrier runway were an intersecting option and a non-intersecting option. It was assumed that triple independent IFR approaches can be conducted when one new runway is available and quadruple approaches can be conducted when two new runways are available. Increased cost savings will be realized if the new westside runway is non-intersecting. In addition, the complexity of operations and controller workload would be less for the non-intersecting alternative. These savings must be weighed against the greater construction costs for a new non-intersecting runway.

G.4.3 Airspace Interactions between DFW Airport and Satellite Airport Traffic

Simulation analyses were conducted to evaluate the capacity and delay impacts of airspace interactions among traffic from various airports in the DFW area. Airspace interaction problems analyzed included the interaction between departures from Dallas Love Field and DFW Airport under both North Flow and South Flow operations, and the interaction between DFW Airport arrivals and Dallas Naval Air Station (NAS) departures and arrivals during North Flow operations.

Simulation results indicate that potential interactions between departures from DFW Airport and Dallas Love Field during South Flow operations are particularly critical. Substantial delay savings result from using routings and procedures that minimize airspace interactions between DFW Airport and Dallas Love Field departures and should be strongly encouraged.

G.5 Expanded East Coast Plan[8]



The purpose of the Airport and Airspace Simulation Model (SIMMOD) application to the Expanded East Coast Plan (EECP) was to support the FAA in its planning efforts to restructure airspace operations on the East Coast of the United States to increase capacity, reduce delays, and improve overall efficiency of the air traffic system.

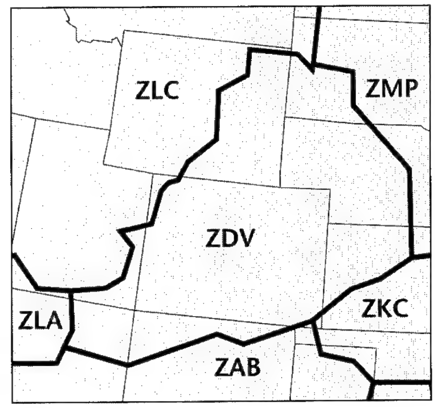
The application effort was concerned with New England's portion of the EECP, which focused on airspace operations in the Boston Air Route Traffic Control Center (ARTCC). Simulation efforts focused on redesigning traffic routings, ATC procedures, and airspace sectors that would properly interface with other portions of the EECP (i.e., the New York area), and that would yield increased capacity and reduced delays in the Boston ARTCC airspace.

Boston Center airspace operations are complex, involving significant East/West and North/South flows. Of the more than 100 airports underlying the Boston Center airspace, Logan International Airport flights account for almost 25 percent of Boston Center total traffic. Traffic handled by the Boston Center includes overflights, arrivals, departures, and intra-center traffic. Because of the geographic location, most flights in the Boston Center are climbing or descending, including intra-center flights, oceanic traffic, and traffic accepted from and handed to adjacent facilities. The climbs, descents, routings, and other airspace maneuvering required by these flights contribute to the complexity of air traffic operations. Adjacent to Boston Center to the southwest is New York Center. Just within the New York Center airspace is a major "hub area," including Kennedy, LaGuardia, and Newark Airports. Many flights departing from or arriving at these airports must transit through Boston Center airspace. Montreal Centre is adjacent to Boston Center to the north. Due to the close proximity of Montreal area airports to the center boundary, much of the traffic to and from Montreal is climbing or descending.

Simulation runs were conducted for both the current Boston ARTCC operations (routes, sectors, and procedures) as well as new proposed EECP operations for a baseline traffic demand schedule.

8. Airport and Airspace Simulation Model (SIMMOD) Application to the Expanded East Coast Plan, October 1987

G.5.1 Current Operations



Operational procedures used under the current system to control aircraft in Boston Center airspace rely primarily on maintaining minimum en route separation requirements. Certain flights, however, have added restrictions placed upon them in the form of specific routing, altitude, and miles-in-trail separation requirements.

For the current system simulation, the standard restrictions that are routinely in effect on a daily basis were assumed. They include miles-in-trail restrictions on aircraft entering Sardi, Stewart, and Pawling sectors for certain periods of the day, and miles-in-trail restrictions on specific Boston Center flights being handed to New York Center and Cleveland Center.

A traffic demand schedule was developed for a baseline day of operations in Boston Center airspace in 1987 which included air carrier, military, air taxi, and general aviation departures, arrivals, and overflights.

G.5.2 Proposed Operations

Major modifications to the current system include:

(1) Boston Center airways were restructured to provide direct routings for established traffic flows with less radar vectoring,

(2) Boston Center departure routes were realigned with revised New York Center EECP routings,

(3) More efficient routings for arrivals into the Boston Center were provided,

(4) Boston Center airspace sectors were revised to efficiently accommodate traffic flows and uniformly distribute the traffic load among sectors,

(5) Airspace sectors were made less complex by reducing the amount of "shelving," i.e., variation of sector shape with altitude, and

(6) TRACONs were delegated more airspace to enhance the efficient use of Tower En Route Control (TEC) routings.

In addition, procedures for metering arrivals into Logan Airport were identified for potential implementation in the proposed EECP system.

Several simulation cases were run. The first analysis was one where no runway constraints were present. It was assumed that the airports can accept arrivals at the rate the airspace can deliver the aircraft to the runway, subject to all airspace route, procedure, and separation constraints. Another case involved having representative airport arrival acceptance rate (AAR) constraints imposed. Two AARs for Logan Airport were selected for the analysis. The first was an AAR of 60 which allowed 34 arrivals per hour on the primary runway and 26 on the secondary runway. The second was an AAR of 36 which allowed 26 arrivals per hour on the primary runway and 10 arrivals on the secondary runway.

It was also decided to evaluate the impacts of arrival sequencing and spacing procedures on delay. In the current system, the primary method for spacing arrivals is to set independent miles-in-trail constraints on the various arrival flows which feed the runways at Logan Airport, so as to stay within the AAR constraints. The use of coordinated arrival metering procedures is being considered for use in the proposed EECP system. Thus, the simulation cases included the AAR 60 and AAR 36 cases, with and without arrival metering.

Simulation results indicate that from a purely airspace point of view, the new proposed EECP airspace routings and sectorizations will result in substantial efficiency and capacity gains. Flight time savings increase as the AAR level is decreased. Additional delay reductions are realized when coordinated arrival metering procedures are used.

An analysis was conducted to evaluate the capacity of the proposed EECP system to handle increased levels of traffic demand, compared to that of the current system.

Simulation results show that the amount of delay at all traffic levels is significantly less for the proposed system than for the current system. It was also found that the proposed system is able to absorb approximately ten percent more traffic before it reaches the same overall delay level experienced in the current system.

Based on an analysis of the sector occupancy statistics, it can be concluded that the proposed EECP system will reduce the intensity of traffic in airspace sectors. The reduced traffic congestion has the potential to alleviate sector saturation, reduce controller workload, and enhance aviation safety.

G.6 New Denver Airport/Airspace Study[9]

The purpose of the New Denver Airport/Airspace Study was to help the FAA's Northwest Mountain Region in their plans to realign en route and Terminal Radar Control (TRACON) airspace so that air traffic operations can be efficiently accommodated at the new Denver Airport. The New Denver Airport/Airspace Study consisted of two airspace options and two runway use plans. Each alternative was analyzed with respect to increasing capacity, reducing delay, and improving efficiency.

Stapleton International Airport is nearing capacity and will not be able to accommodate traffic forecasts of 1,900 operations per day in 1993. The city of Denver, Colorado is planning to replace Stapleton International Airport with a new airport in order to accommodate the forecast increases in traffic. The new Denver airport will be located approximately 10 miles northeast of Stapleton International Airport and is scheduled to open in 1995 with five runways. Existing plans for the new airport include expansion to twelve runways as the traffic demand increases to 3,600 operations per day.

The six runway configuration consists of four north/south runways (two on either side of the terminal area) and two east/west runways. One is located north of the two runways on the right side of the terminal area and the other is located south of the runways on the left side of the terminal area. All runways are 12,000 feet long with the exception of one runway that is 16,000 feet long. The runway spacing is large enough for three simultaneous ILS approaches during IFR conditions. The airport is primarily a north/south flow airport; the two east/west runways are used as offload runways during north or south flow operations.

The new Denver Terminal Radar Approach Control (TRACON) will be operated as an arrival/departure gate system. Two arrival/departure gate options and two runway utilization plans were analyzed.

G.6.1 Terminal Airspace Design Evaluation

The TRACON airspace for the New Denver Airport is bound by a circle, centered at the New Denver Airport, with a radius of 30 nautical miles, and extends from the ground to

9. New Denver Airport/Airspace Study, October 1989

20,000 feet in altitude. The basic design involves four arrival and four departure gates to accommodate traffic associated with the New Denver Airport and satellite airports (Jeffco, Centennial, and Front Range). Two options for placement of the arrival/departure gates were analyzed. Option 1 involves roughly symmetric distribution of arrival and departure gates around the boundary of the TRACON. The arrival gates are placed so that existing airways that feed the arrival gates at Stapleton International Airport can be used. In Option 2, the arrival gates are moved so that the north and south departure gates are smaller.

Simulation results show that Option 1 provides more capacity and more efficient operations than Option 2. Delay reductions and more efficient airspace routings result in substantial savings in aircraft operating time for Option 1.

G.6.2 Runway Use Analysis

The New Denver Airport is scheduled to open in 1995 with a five-runway configuration. Two runway use plans were evaluated. The plans differ in terms of criteria for offloading aircraft from the primary runways during arrival and departure peaks. Plan 1 assumes the use of procedures similar to those currently used at Stapleton International Airport. Plan 2 involves more demand-responsive use of runways, with the number of arrival and departure runways varying with demand, and with balanced utilization of available runway capacity.

The runway utilization for departure rushes under Plan 1 is the same for VFR and IFR operations, where up to four runways are available to handle the departure rush. During a VFR arrival rush, up to five arrival runways are available, depending on the size of the arrival rush. The runway use is balanced so that arrivals are evenly allocated to the arrival runways, and departures are evenly allocated to departure runways. The main difference between VFR and IFR operations is the number of arrival runways. Only three arrival runways are available for IFR operations because the east/west runways become departure runways.

Under Plan 2, the departure rush runway utilization is the same for VFR and IFR operations as it is for Plan 1. During a VFR arrival rush, four runways are always available for arrivals. The arrival and departure use is not balanced. As in Plan 1, only three IFR arrival runways are used.

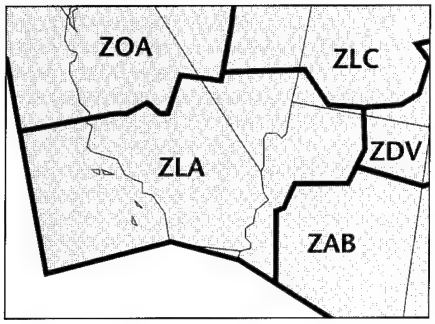
Simulation results show that substantial benefits may be realized using Plan 2 instead of Plan 1.

G.6.3 New Denver Airport and Terminal Airspace Capacity Analysis

The traffic demand at the New Denver Airport is forecast to be 1,900 daily operations when it opens in 1995. This was used as the baseline demand. An analysis was conducted to evaluate the capacity of the New Denver Airport and terminal airspace using airspace Option 1 and runway use Plan 2. The analysis was conducted for VFR and IFR operations with baseline and increased demand in increments of 10 percent, up to a 50 percent increase over the baseline demand.

Simulation results show that there is sufficient airspace and runway capacity to accommodate future growth with six runways when the runways are used efficiently. The use of airspace Option 1 and runway use Plan 2 will provide adequate capacity to accommodate expected future traffic growth of up to 30 percent over baseline demand with modest increases in annual delay. For demand increases greater than 30 percent over baseline, additional runway capacity at the New Denver Airport will be required to avoid substantial increases in delay.

G.7 Los Angeles Airspace Project[10,11]



The purpose of the Los Angeles Airspace Capacity Project was to support the FAA Western-Pacific Region in their planning efforts and analyze several critical capacity and delay problems and issues in the Southern California area.

Los Angeles Center airspace operations are complex, involving significant East/West and North/South flows. Traffic handled by the Los Angeles Center includes overflights, arrivals, departures, and intra-center traffic. Because of its geographic location, most flights in the Los Angeles Center are climbing or descending. Los Angeles International Airport flights account for almost 30 percent of Los Angeles Center total traffic.

Immediately adjacent to and to the north of Los Angeles Center is Oakland Center. Flights between Oakland Center and Los Angeles Center departing from or arriving at Los Angeles Basin airports must transit the Ventura/Palmdale corridor, one of four primary corridors available for ingress or egress into the Los Angeles Basin area. These corridors are a result of the numerous Special Use Airspaces (SUAs) which exist within and immediately adjacent to Los Angeles Center. The Ventura/Palmdale corridor is one of the busiest in the world and requires special flow management to maintain maximum capacity usage during peak traffic periods.

The Los Angeles Airspace Capacity Project consisted of three major simulation analysis tasks. They are: (1) Los Angeles International Airport capacity analysis; (2) Los Angeles Center airspace choke point delay analysis; and (3) Los Angeles Basin airspace realignment analysis. Results of each were analyzed with respect to increasing capacity, reducing delay, and improving the overall efficiency of air traffic operations and are summarized below.

G.7.1 Los Angeles International Airport Capacity Analysis

The objective of this task was to determine the arrival and departure capacity of Los Angeles International Airport under various operating conditions and the sensitivity of the airport capacity to variations in key operational parameters.

10. Los Angeles Airspace Capacity Project, December 1988
11. Los Angeles International Aiport Capacity Enhancement Plan, September 1992

Simulation results show that under baseline operating conditions, the maximum arrival/departure capacity of Los Angeles International Airport was 138 operations per hour during IFR conditions and 166 operations per hour under VFR conditions. However, high levels of delay would occur if the airport were operated at capacity. For baseline operating conditions, the level of operations under which delays remain small are approximately 116 operations per hour under IFR conditions and 140 operations per hour under VFR conditions.

The goal of the Capacity Design Team at Los Angeles International Airport was to develop an action plan of alternatives to increase airport capacity, improve airport efficiency, and reduce aircraft delays. These must coincide with improvements mentioned above if maximum capacity is to be realized. Those recommendations that directly relate to airport capacity at the airport can be found in Appendix C.

Recommendations for Los Angeles International Airport designed for airfield improvements included: constructing departure pads (staging areas) at ends of runways, extending taxiways, constructing high-speed taxiways, and extending Runway 24R. Facility and equipment improvements recommended included upgrading the ILS on Runway 25L to CAT III.

G.7.2 Airspace Choke Point Delay Analysis

The flow of traffic in the Los Angeles Basin is affected by large areas of Special Use Airspace. There are four major choke points through which traffic to and from the Los Angeles Basin must pass due to Special Use Airspace.

The fact that these choke points cause delay for flights transiting these corridors has been observed by the FAA for some time. Speed reductions, path stretching, and other controller techniques initiated during peak traffic demand periods provide evidence that delay does occur.

Simulation results show that substantial delays are incurred by traffic passing through choke points in Los Angeles ARTCC airspace. Modest increases in traffic volume will result in substantial increases in delay unless choke point constraints are released to increase capacity.

G.7.3 Los Angeles Basin Airspace Realignment Analysis

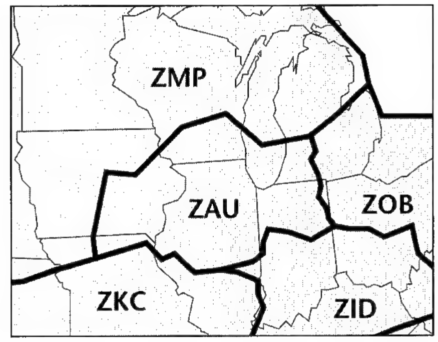
A saturation problem exists in the Los Angeles Center which constrains the capacity of the airspace structure. It is primarily due to the complexity and intensity of operations in Sector 21 of the Los Angeles Center. Sector 21 is a relatively small sector encompassing, at its maximum, a distance of approximately 35 miles from north to south and 50 miles from east to west. The bottom of Sector 21 airspace commences at an altitude of 7,000 feet and reaches its highest altitude at FL230.

The workload complexity factors associated with Sector 21 traffic flow are as a result of the fact that (1) the majority of traffic tends to converge to one point within Sector 21; (2) the closure rate between aircraft is significantly high, especially in head-on situations; (3) lower performance aircraft must be interleaved with the higher performance jet traffic, which complicates operations; and (4) within the limited airspace available, traffic flows must be merged to satisfy minimum separation standards required under the en route airspace environment.

Potential airspace and routing changes for Sectors 21 and 22, and Los Angeles and Coast TRACONs were defined. Major modifications to the old system included expanding the lateral boundaries of Coast TRACONs, establishing a common ceiling of 13,000 feet for Coast and Los Angeles TRACONs, and rerouting departures from Los Angeles International, Orange County, and Long Beach Airports to the Coast TRACON.

Simulation results show that realignment of the Los Angeles Basin airspace will relieve the airspace saturation in Los Angeles ARTCC Sector 21 and result in substantial improvements in efficiency. Airspace capacity will be substantially increased in the new airspace realignment enabling increased volumes of traffic to be handled with less delay. For the near-term traffic demand, delay will be five times greater under the existing airspace structure than with the new realigned airspace and at a level of 40 percent increase in traffic (the nominal forecast projection), the delay is nine times greater under the old system than the new system. The airspace realignment will increase traffic loading for both Los Angeles and Coast TRACONs. This increased traffic can be accommodated without increased delay, assuming that sufficient controller staffing is available to provide adequate sectorization of the terminal airspace.

G.8 Chicago Airspace Project[12,13]



The purpose of the Chicago Airport/Airspace Capacity Project was to support the planning efforts of the FAA's Great Lakes Region in evaluating alternatives addressing capacity and delay problems in the greater Chicago metropolitan area. Potential solutions involved operational alternatives that included airspace realignment, route redesign, new runways, and revised procedures to enhance the efficiency and safety of air traffic operations. The operations of primary concern were en route and terminal airspace operations in the Chicago Air Route Traffic Control Center (ARTCC), terminal airspace operations in the Chicago Terminal Radar Approach Control (TRACON), and airfield operations at Chicago O'Hare (ORD) and Midway (MDW) Airports.

The Chicago TRACON provides air traffic control services in the terminal airspace encompassing O'Hare Airport and several other satellite airfields. In addition to O'Hare Airport, the primary airport, there are 23 satellite airports controlled by the different control positions within Chicago TRACON.

The simulation analysis involved various scenarios using the existing airfield facilities, proposed airfield improvements at O'Hare Airport, and the existing and proposed airspace systems. Various weather conditions and traffic demand levels were simulated to provide an adequate assessment of the relative benefits or drawbacks of the various airfield/airspace options. The runway options and alternatives for O'Hare Airport that were simulated included existing runways and the potential options of adding one or two new air carrier runway(s), including changes in operational procedures and realignment of Chicago Center airspace.

G.8.1 Baseline Operations

The existing airfield of Chicago's O'Hare International Airport consists of three sets of parallel runways: a pair of northeast/southwest runways, a pair of southeast/northwest runways, and a pair of east/west runways. In addition, a smaller general aviation commuter north/south runway is located north of the terminal area, but is used only sparingly.

12. Chicago Airport/Airspace Capacity Project, June 1990
13. Chicago Delay Task Force: Delay Reduction/Efficiency Enhancement Final Report, April 1991

The existing airspace system utilizes a four "cornerpost" design for arriving aircraft bound for airports within the Chicago TRACON. The en route system uses a network of airways to merge O'Hare Airport traffic entering the terminal area over the four cornerposts. Aircraft depart the Chicago TRACON airspace in the existing airspace system initially on the four cardinal directions, i.e., north, south, east, and west. Traffic departing satellite airports, with a few exceptions, are provided in-trail spacing with O'Hare departures proceeding over a common fix.

Simulation results of baseline operations show that the predominantly east and west direction of flow of inbound flights to O'Hare Airport, along with the present location of the four cornerposts, results in uneven loading of two cornerposts during peak arrival periods. These traffic flow imbalances at the arrival fixes result in delay as inbound traffic is constrained during these uneven loading situations.

O'Hare Airport arrival traffic on the baseline day was not allowed to free flow through the four cornerposts, that is, special miles-in-trail (MIT) separation restrictions between successive arrivals over a cornerpost were used. Output results revealed that the imposition of MIT restrictions on arrivals over the cornerposts will result in delay increases.

Additional runs were made to evaluate delay impacts of future traffic demand projections, for the short term and the long term, using the baseline airport/airspace system. Simulation results indicate that capacity of the baseline airport/airspace system is not sufficient to accommodate anticipated traffic growth at O'Hare and Midway Airports, thus resulting in substantial delay penalties.

G.8.2 Short-Term Operational Alternatives

The specific alternatives evaluated involved a set of short term airspace realignment and procedural changes that could be implemented over several months. These changes, which were aimed at reducing traffic complexity and workload in the Chicago area airspace to enhance safety, while maintaining the efficiency of operations, included:

(1) rotating the four arrival cornerposts by 45 degrees to the four cardinal directions: north, south, east, and west,

(2) raising the ceiling of the TRACON airspace,

(3) removing holding patterns from the TRACON airspace to provide a dedicated departure corridor for Midway Airport,

(4) establishing merge points for arrivals farther from the TRACON boundary,

(5) eliminating the WHETT departure fix to allow a dedicated departure corridor for Midway traffic, and

(6) establishing a dedicated departure corridor for Midway traffic.

Simulation results show that substantial delay and cost savings would be realized using the short term airspace realignment and procedural changes (without MIT restrictions) described above.

G.8.3 Long-Term Operational Alternatives

The long term options, aimed at increasing capacity and reducing delays in the Chicago area, included building one or two new runways at O'Hare Airport and/or rotating the four arrival cornerposts by 45 degrees to the cardinal directions (as analyzed in the short term alternatives). The benefits of the new runways include capacity gains due to utilizing triple independent approaches in both VFR and IFR. The rotation of the O'Hare TRACON arrival cornerposts increases the number of south satellite arrival fixes by 50 percent (three versus two), allows departures to the south to operate independent of O'Hare Airport traffic, and provides added vectoring-sequencing airspace within the O'Hare TRACON. High performance jet traffic destined to Midway Airport, approaching from a northerly direction would be able to remain at higher altitudes longer, resulting in an operating cost savings for those Midway Airport arrivals.

Simulation results show that delay savings are realized by utilizing the proposed cornerpost rotation and are a result of additional aircraft flowing through arrival fixes and taking advantage of previously unused runway capacity at O'Hare Airport. Delay savings are realized only during VFR operations, because, during operations under IFR, the runway capacity available at O'Hare Airport is not sufficient to take advantage

of the airspace capacity gains afforded by the rotated cornerposts. Thus, runway capacity at O'Hare must be increased if the potential benefits of the new airspace capacity are to be realized during IFR conditions.

The addition of two new runways at O'Hare Airport, while utilizing the existing airspace system, provides a reduction in operational complexity, yielding potential safety enhancements, large gains in airport capacity when operating under IFR, and equalized airport capacity during VFR and IFR operations.

Rotation of the arrival cornerposts and addition of two new runways at O'Hare Airport result in substantial delay savings under both VFR and IFR operations. Under VFR, the capacity increases afforded by the new rotated airspace allow full utilization of the new runway capacity. Under IFR, the new airspace provides added flexibility for balancing the use of the new runways, thus yielding greater delay savings than with the existing airspace system.

Additional simulation runs involved assessing the impact of adding only one new runway at O'Hare Airport, while still maintaining the existing four cornerpost system and the case where the arrival fixes are rotated 45 degrees and one new runway is added at O'Hare Airport.

The Final Report of the Chicago Delay Task Force identifies constraints which currently exist in the Chicago airport and airspace operating environment and defines options to explore further which will alleviate these constraints, thereby reducing delays at Chicago's airports. The Chicago Delay Task Force's recommendations are outlined in Appendix C.

The Chicago Delay Task Force issued its final report in April 1991. Since that time, the FAA Great Lakes Region and the City of Chicago have organized the Chicago/FAA Delay Task Force Implementation Team. That team consists of the Airport Technical Working Group and the ATC Technical Working Group.

The Airport Technical Working Group was developed to facilitate implementation of Delay Task Force airport improvement recommendations. The projects selected for the near term are: flow-through aircraft hold pads, Runway 4R angled exit taxiway, and northward relocation of Runways 9L/27R and 4L/22R.

The ATC Technical Working Group was formed to facilitate implementation of Delay Task Force airspace recommendations. The projects currently being analyzed include restructuring of the Chicago airspace and additional CAT II/III approach capability.

Appendix H

New Technology for Improving System Capacity

H.1 Background

The demands on the National Airspace System (NAS) are continuously growing, and this increasing demand must be accommodated with limited airport and airspace capacity. New and changing technologies provide the opportunity to dramatically improve the efficiency and effectiveness of the NAS. One of the major purposes of the Research, Engineering, and Development (RE&D) program is to develop and exploit technologies that will increase system capacity and fully utilize existing capacity resources, while maintaining or improving the current level of safety.

H.1.1 Major Accomplishments

- Approved instrument approach procedures for triple parallel runways at 5,000 feet apart.
- Completed testing of Airport Movement Area Safety System (AMASS) at San Francisco International Airport.
- Successfully demonstrated automatically controlled runway status light system at Boston Logan International Airport.
- Developed standards for stop bar system for controlling aircraft movement in low visibility.
- Developed the Traffic Alert and Collision Avoidance System (TCAS) which will be installed on all airliners operating in the United States.
- Demonstrated digital Automated Terminal Information System (ATIS) at three airports.
- Began field development of Center-TRACON Automation System (CTAS).
- Implemented Converging Runway Display Aid (CRDA) at Lambert St. Louis International Airport.
- Approved procedures for 5,000 certified Global Positioning System (GPS) non-precision approaches at 2,500 airports in the United States.
- Completed avionics certification standards for Global Navigation Satellite System (GNSS).
- Completed avionics certification standards for supplemental GPS use over the ocean.
- Provided regulatory and implementation materials in support of 1,000 foot vertical separation standard in the North Atlantic.
- Developed flexible track generation and traffic advisory capabilities in the Central Pacific.
- Validated innovative deicing protection technologies and certification techniques.
- Established multi-agency program to provide real-time weather information to pilots and controllers.
- Demonstrated improved thunderstorm forecasting capability.
- Completed ground testing of airborne humidity sensor.
- Completed flight experiments of wind shear detection system.
- Developed traffic management display system.
- Began implementation of automated demand resolution functions.
- Delivered testbed for digital voice communications.
- Developed prototype two-way data communications system for ATC clearances.
- Established predeparture clearance procedures at 31 airports.
- Developed a long- and short-term pavement research plan.
- Completed development of layered elastic theory for pavement design.
- Completed design of pavement testing machines.

The FAA has developed a description of the Air Traffic Management (ATM) system of the future that has broad support from the RE&D Advisory Committee, aviation system users, and the aviation industry as a whole, including the international community through the International Civil Aviation Organization (ICAO). A strong RE&D program is essential to bringing this vision of the future to operational reality. Among the elements of the ATM system of the future are:

- Satellite communications technology for air-to-ground communications over oceans and sparsely populated areas.
- Satellite navigation systems to provide location information over oceans and less developed parts of the world and provide high quality approach guidance to any runway end anywhere in the world.
- ATC digital data link communications to connect aircraft systems with ATC automation systems and increase safety by reducing misunderstood communications.
- Airborne collision avoidance systems, in themselves a major safety tool, have the potential to create, in the cockpit, a valuable picture of the traffic situation around the aircraft. Working with the ATC system, these capabilities will lay the basis for a system having greater capacity and enhanced safety.
- Flight management systems, increasingly available in modern transport aircraft, can facilitate major improvements in working with ATC to create optimal flight profiles.
- Air traffic management and control automation technology will create major improvements in strategic flow management across the country, providing users with more direct routes. Automation in terminal airspace will significantly increase capacities while reducing controller workload.
- Better air traffic surveillance systems, e.g., Mode S secondary surveillance radar, satellite and terrestrial-based Automatic Dependent Surveillance (ADS), new surface surveillance tools, and fast-scan radars, will revolutionize the ability to track multiple aircraft positions.
- Better ways to acquire and use weather and environmental data are on the horizon. Major strides have been made in detecting wind shear, gathering winds aloft data, and forecasting severe storms. Reducing the impact of wake vortices, a detriment to airport capacity, is possible.
- Airway Facilities Operation Control Center will improve the operational integrity of all fielded systems.

The projects described above are explained in detail in the following sections: *Capacity and Air Traffic Management Technology; Communications, Navigation, and Surveillance; Weather; and Airport Technology.*

H.2 Capacity and Air Traffic Management Technology

H.2.1 Advanced Traffic Management System (ATMS) (021-110)

Responsible Division: ARD-100
Contact Person: Stephen M. Alvania, 202/267-3078

Purpose

To reduce delays and enhance operating efficiencies through a highly automated traffic management system.

The ATMS program is the FAA research and development effort in direct support of the operational Enhanced Traffic Management System (ETMS). The ATMS is used to investigate automation and technology applications that will enhance the operational capabilities of the FAA Traffic Management System. The ATMS program is structured as the development of a sequence of evolutionary flow management capabilities which, once determined to be operationally beneficial, migrate to the operational ETMS system through a common development/testbed facility. The ATMS evolutionary stages currently defined are: Aircraft Situation Display (ASD) to display the traffic situation; Monitor Alert (MA) to automatically alert flow managers to projected congestion and delay conditions; Dynamic Special Use Airspace (DSUA) to integrate military airspace planning into the civil flow management process; Automated Demand Resolution (ADR) to generate alternative flow management strategies that deal with the projected conditions; Strategy Evaluation (SE) to evaluate the operational impact of those alternative strategies; and Automated Execution (AEX) to automatically select and implement the "best" strategy.

Program Milestones

The Aircraft Situation Display (ASD) and Monitor Alert (MA) functions have been deployed as part of the operational ETMS at the Air Traffic Control System Command Center (ATCSCC), all ARTCCs, and selected TRACONs.

Prototype Automated Demand Resolution (ADR) algorithms are being designed and incorporated into the ATMS testbed for evaluation. During FY93 and FY94, these algorithms were tested and refined. Migration to the ETMS is expected in FY95.

The development of the Strategy Evaluation (SE) function began in FY93 with migration to the ETMS anticipated in FY96.

The development of initial Dynamic Special Use Airspace (DSUA) algorithms began in FY93 and will continue with migration to the ETMS anticipated in FY97.

The Automated Execution (AEX) function will provide the data communications that will support the ADR and SE functions. AEX will be significantly more sophisticated than previous stages. Development of this function will occur concurrently with the ADR and SE functions. .

Products

- Aircraft Situation Display (ASD) functionality
- Monitor Alert (MA) functionality
- Prototype Automated Demand Resolution (ADR) functionality
- Prototype Strategy Evaluation (SE) functionality
- Prototype Automated Execution (AEX) functionality
- Prototype Dynamic Special Use Airspace (DSUA) functionality

H.2.2 Oceanic Air Traffic Automation (021-140)

Responsible Division: ARD-20
Contact Person: Jim McDaniel, 202/267-3534

Purpose

To increase oceanic air traffic capacity and efficiency by providing automation for oceanic airspace.

The current oceanic environment has no radar coverage. Navigation is handled using only aircraft onboard systems; air traffic operations are performed either manually or with limited automation. Air/ground communications are through a third party service provider via high frequency radios.

When fully developed, the automated oceanic air traffic management system will provide airspace structuring that will reduce controller workload and safely increase system capacity to help cope with the ever-increasing demand for transoceanic travel. This project will combine three oceanic RE&D projects: ADS, Oceanic Traffic Planning System (OTPS), and Oceanic Automation.

Research and development studies will identify new air traffic control procedures and the automation necessary to increase airspace user's operating efficiency. The studies will focus on airspace utilization, system development, and advanced functions.

The OTPS project will provide oceanic traffic managers with automated information gathering techniques and route development and analysis tools to provide better fuel economies and time efficiencies to users in oceanic airspace. Development efforts include the functions of generating flexible tracks to take advantage of favorable wind conditions, providing traffic managers with a traffic display system to graphically display aircraft positions over the oceanic airspace,. and a track advisory function that interactively provides airlines, before their oceanic gateway entry, with gateway loading delays for air carriers, and reduces workload for controllers. Also, traffic management capabilities will be developed for automating the transfer traffic management information between international ATC facilities and aeronautical operation controls (AOCs). All of these oceanic traffic management functions will eventually be integrated with the domestic enhanced traffic management system (ETMS).

Another project is developing ground-based systems using ADS technology and satellite communications links. Development efforts will upgrade oceanic display and planning system (ODAPS) technology with new displays and controller input-output devices. Future developmental efforts will include electronic ATC clearance delivery to aircraft, enhanced conflict detection and resolution, and electronic flight data displays.

Standards, requirements, and procedures will be thoroughly tested to validate system performance and capabilities prior to any production decision. An initial testing capability exists at the Oceanic Development Facility (ODF) and it will be enhanced to conduct the full-range testing that will be required, such as using real satellites, real ground/earth stations, and aircraft cockpits to identify total system performance and highlight areas needing improvements.

Program Milestones

In FY93, a Separation Improvement Program Plan was developed and analysis was completed for a U.S.-led initiative to reduce oceanic separation standards. The ground/ground data communications function that lays the groundwork for full two-way data link communications between pilots and controllers was completed. An interim situation display was installed at ODF.

In 1995, efforts will continue toward coordinating industry standards in the areas of avionics characteristics and minimum operational performance standards. Engineering trials in the Atlantic and Pacific will be completed. These trials will be used for developing requirements and standards for ADS functions, dynamic rerouting, track generation, and other oceanic automation features.

Also in 1995, an ODAPS central processor replacement effort and an oceanic electronic flight data display computer human interface study will be completed. These studies will be used in 1996 with a study on ADS reporting rates to support the transition of ODAPS to an advanced oceanic automation system.

Electronic flight data and a conflict detection/resolution capability will be delivered to the ODF in 1997. Development will continue on display enhancements for integration into the interim situation display hardware. The ODF will be completed in 1995 when the cockpit interface to the end-to-end simulation capability is installed.

In 1996 through 1998, studies for advanced functions will be completed, the air traffic management project will expand the South Pacific strategic planning system concept to incorporate foreign traffic management systems. Also during that time, a final software version of the electronic flight strips and conflict detection/resolution capability will be completed to provide controllers with aircraft separation recommendations.

Products

- Ground/ground data communications capability
- Oceanic controller situation display
- Oceanic traffic planning and management functionality into domestic TMS
- Oceanic airspace coordination function
- Automated data interchange/transfer to and from foreign Civil Aeronautics Administrations
- Two-way communications between aircrews and oceanic controllers
- Enhanced conflict detection/resolution capability
- Next generation flight data processor
- Track advisory capability for Anchorage and New York oceanic centers

H.2.3 Terminal ATC Automation (TATCA) (021-180)

Responsible Division:	ARD-40
Contact Person:	Chuck Friesenbahn, 202/267-3808

Purpose

To develop automation aids to assist air traffic controllers and supervisors by providing advisories designed to optimize the flow of traffic in the terminal area and to facilitate the early implementation of these aids at busy airports.

The TATCA program consists of three projects to assist air traffic controllers. These projects are: the Converging Runway Display Aid (CRDA), the Center-TRACON Automation System (CTAS) and the Controller Automation Spacing Aid (CASA). CRDA provides geometric spacing aids for aircraft by means of software changes within existing ARTS terminal radar processors. A Federal Aviation Order (7110.110) governing dependent converging instrument approaches utilizing CRDA was signed November 30, 1992.

The CTAS project is now in full-scale field development and consists of the following tools: a comprehensive traffic planning and scheduling tool known as the Traffic Management Advisor (TMA) for the Air Route Traffic Control Center (ARTCC), a Descent Advisor (DA) for en route controllers, a turn and speed advisor for terminal controllers known as the Final Approach Spacing Tool (FAST) and an ascent trajectory synthesis tool for departing aircraft known as Expedite Departure Path (EDP).

Longer term TATCA activities focus on fully developed terminal automation techniques integrated with other ATC and cockpit automation capabilities of the Advanced Automation System (AAS) and other ATC and cockpit automation capabilities.

Program Milestones

TMA is currently being evaluated and demonstrated in the Denver ARTCC. Further field evaluation for TMA and FAST will take place at the Dallas/Fort Worth Center in FY93 and continue in 1994. Laboratory development of DA and EDP is continuing.

Products

Major CRDA milestones include:

- Begin national implementation 07/92

Major TMA milestones include:

- Field Concept Development and Evaluation 08/92
- Limited Deployment 10/94

FAST milestones include:

- Fast Functionality in FDADS 08/92
- Field Concept Development/Evaluation 05/93
- Begin Limited Deployment 04/96

DA milestones include:

- Develop Prototype Software 07/93
- Deploy DA in ISSS 04/95
- Develop DA in ACCC 04/98

EDP milestones include:

- Field Concept Development 04/95
- Begin Limited Deployment 04/97

CASA milestones include:

- Begin Limited Deployment 06/95

TATCA/AAS milestones include:

- Modification to the System Level Specification for the AAS 06/94
- Integrated TATCA with ACCC 06/94

H.2.4 Airport Surface Traffic Automation (ASTA) (021-190)

Responsible Division: ARD-50
Contact Person: John Heurtley, 202/646-5566

Purpose

To provide controllers with automatically generated alerts and cautions in all weather conditions and data TAGS to identify all aircraft and special vehicles on the airport movement area.

To develop airport surface surveillance, communications, and automation techniques that will provide an effective runway incursion prevention capability by using ground sensor primary radar Airport Surface Detection Equipment (ASDE-3), Automated Radar Terminal System (ARTS), Differential-Corrected Global Positioning System (DGPS), and Airport Movement Area Safety System (AMASS).

The ASTA program has historically consisted of two major elements: surface safety automation and surface traffic automation. The surface safety automation element is composed of the Airport Movement Area Safety System (AMASS) and the Runway Status Light System (RSLS). ASDE-3/AMASS provides automatically generated alerts and cautions of impending runway incursion situations directly to the controllers. AMASS is currently in acquisition, but additional research and development of staged improvements using sensors other than the ASDE-3 may be undertaken. The RSLS automatically operates lights at all runway entranceways and at the take-off hold position to directly indicate to the pilots that the runway is "hot," i.e., there is an airplane on close final approach or on departure. RSLS is presently being implemented at Boston Logan International Airport for operational suitability assessment from 1995 to 1996.

The surface traffic automation element will develop means to provide identification TAGS for all aircraft and vehicles on the airport movement area and all aircraft in ramp and limited gate areas. The TAGS are to be displayed on the ASDE-3 display. Also to be developed is a surface traffic planner that will be integrated in an optimal manner with TATCA automation for aircraft on approach and DSP automation for aircraft on departure. Surface traffic planning automation will assist the tower and ramp controllers in reducing taxi-out delays and thereby increase airport capacity.

The surface traffic automation part of ASTA consists of three subsystems. Commercial Air Carrier Identification combines Differential Global Positioning System

(DGPS) and other surface sensors with a surveillance data link to provide positive identification of all commercial air carriers. General Aviation/Vehicles Identification will likely use a form of positioning TAG determination based on the MODE-A 4096 code. Traffic Planner/Conformance Monitor will process track and flight data to provide the controller with automated traffic plan assistance in all weather conditions and will also provide taxi route conformance monitoring.

All airports that are slated to receive ASDE-3/AMASS equipment under the F&E program will also receive TAGS and the ASTA Traffic Planner. For those airports not equipped with ASDE-3/AMASS, other airport surface sensors, such as the DGPS surveillance data link coupled with a "low-cost" ASDE may be used.

Program Milestones

The ASTA project was started in FY89 to reduce the risk of runway incursions and improve airport capacity through increased efficiency of aircraft surface movements and better departure traffic management. In FY90, alternative capabilities for reducing runway incursions were identified. In FY93, contracts were awarded to demonstrate alternative technologies to prevent runway incursions, the third AMASS was established at Boston Logan International Airport to provide an ASTA DGPS testbed, and the RSLS was successfully demonstrated to industry at Boston Logan.

In 1994, a Request For Proposal (RFP) for limited competitor selection will be issued, and contract award will be June 1995. Full Scale Development (FSD) for the commercial aircraft TAGS subsystem will be May 1996, with first Operational Readiness Date (ORD) June 1998. FSD for general aviation/vehicle TAGS will be September 1996, with first ORD March 1999. The ASTA Traffic Planner FSD (first implementable package) is planned for March 1997, with first ORD July 1999.

H.2.5 Tower Integrated Display System (TIDS) (021-210)

Responsible Division: ARD-100
Contact Person: Bob Sheftel, 202/267-7645

Purpose

To consolidate the displays and instrumentation used in towers for airport environmental data and control equipment, thus facilitating the installation of future tower systems such as TCCC.

This project is divided into two phases. In Phase I, a market survey will be conducted to determine the availability of systems meeting the requirements of Air Traffic with a minimal development effort. The results of the market survey will be used to determine an initial set of TIDS requirements and an appropriate acquisition strategy so as to field TIDS in the near term. These requirements will be developed through a team effort within the FAA. Documentation for transition to a Facilities and Equipment (F&E) program will be developed, including the program documents and production specifications to support implementation of the initial TIDS.

Phase II will be initiated in parallel with Phase I. Phase II will assess and integrate TIDS enhancements packages to meet the full range of Air Traffic's TIDS requirements.

Program Milestones

TIDS has been in hold status since mid-FY93 pending a decision on the deployment of TCCC. In FY94, a specification and statement of work for an initial TIDS contract was completed in preparation for release of an RFP. Upon receipt of a decision to proceed, the specification and statement of work will be revised and contracting activity will resume. Integrated Operational Test and Evaluation activities will be completed using the TIDS prototype, and this will lead to a potential initial TIDS deployment. TIDS enhancement activities will continue, leading to a potential first enhancement package. Other enhancement packages will continue to be investigated.

Products

- Initial TIDS requirements
- Prototype TIDS
- TIDS enhancement requirements
- TIDS enhancement prototype

H.2.6 Multiple Runway Procedures Development (021-220)

Responsible Division: ARD-100
Contact Person: Gene Wong, 202/267-3475

Purpose

To develop ATC concepts and procedures to reduce airport delays by more fully utilizing the capacity of multiple runway configurations during Instrument Meteorological Conditions (IMC).

Air traffic procedures and flight standards criteria for simultaneous dual, triple, and quadruple Instrument Flight Rules (IFR) parallel approaches will be developed and validated. Requirements and techniques for improved surveillance, navigation, and ATC display capabilities will be developed to support these procedures.

Studies sponsored by the FAA and the aviation industry have identified technical and operational concepts with the potential to reduce airport arrival delays by better utilizing multiple runway configurations in IMC. These concepts include the use of improved and current monitoring systems for conducting simultaneous approaches to dual, triple, and quadruple parallel runways. Improved monitoring technology includes precision runway monitor (PRM) systems, as well as high resolution ATC displays with controller alert aid and Airport Surveillance Radar-9 (ASR-9) or Mode S. Such displays are referred to as the Final Monitor Aid (FMA). Promising concepts will be validated through ATC simulations and, in some cases, full-scale demonstrations at airports.

Multiple IFR parallel approach procedures for Dallas/ Ft. Worth Airport, which has planned the addition of third and fourth parallel runways, were developed in order to gain technical and operational insights, as well as to help expedite the implementation of such procedures. This procedure was site specific and was developed based on the use of current ARTS displays and ASR-9. This was followed by the development of national standards for triple and quadruple IFR parallel approaches based on the current ARTS display and ASR-9 capabilities.

The FAA has completed demonstrations of electronically scanned and "back-to-back" antenna PRM technologies resulting in the acceptance of simultaneous approaches to parallel runways spaced as closely as 3,400 feet. This project will conduct additional analyses and simulations to investigate the combined use of improved data rate PRM technology with highly accurate navigation/landing systems, such as satellite navigation system, microwave landing system, and state-of-the-art autopilot to further reduce the spacing standards of parallel runways. The results of these studies for dual parallel runways will also provide the basis for the analysis of spacing standards for closely spaced triple parallel runways. The final phase of the multiple runway procedures development will focus on quadruple parallel runways.

Program Milestones

In FY91, simulation evaluation of simultaneous IFR approaches to triple parallel runways spaced 5,000 feet apart, using ASR and ARTS displays, was completed. Simulations of triple parallel IFR approaches to runways spaced 4,300 feet apart using ASR-9 and high-resolution color displays with automated alerts were performed in FY92. Additional simulations to investigate the feasibility of using high-resolution color displays with automated alerts and ASR-9 to reduce dual and triple parallel runway spacing standards to 4,000 feet were conducted in FY92. Simulations of dual and triple runways spaced 3,000 feet apart, using the PRM system, were conducted in FY92. Simulation evaluation of the use of offset localizer and PRM to reduce the dual parallel runway standard to 3,000 feet were initiated in FY92.

In FY93, the FAA approved national standards for triple simultaneous parallel approaches. Such approaches may be conducted to runways spaced a minimum of 5,000 feet apart using current surveillance equipment (ARTS controller displays and ASR-9 radar sensors), provided that the airport elevation is less than 1,000 feet above sea level. At higher elevations, or for runway spacings between 4,300 and 5,000 feet, triple simultaneous approaches may be conducted if the monitor controller uses an FMA display.

The thinner air at higher elevations leads to higher ground speeds for aircraft on final approach. These higher ground speeds in turn mean that in the event of a blunder on final approach, the blundering aircraft can cross the distance between the parallel runways more quickly. Simulations of the new Denver International Airport (DEN) (elevation 5,200 feet) conducted at the FAA Technical Center confirmed this effect. However, these simulations also confirmed the benefit of using FMA displays, which enable the controller to detect a blunder much sooner than the current ARTS displays. FMAs have been installed at DEN, and the first triple simultaneous instrument approaches in the world will be conducted when the new airport opens in FY94.

Simulations to be conducted at the FAA Technical Center in FY94 will help to establish national standards for dual simultaneous approaches to runways as close as 3,000 feet. Such operations would be beneficial at New York's John F. Kennedy International Airport (JFK), where Runways 22R and 22L are 3,000 feet apart, and at Philadelphia International Airport (PHL), where a new commuter runway is planned to be built at that spacing.

Products

- Recommendation on ATC procedures
- Simulation analysis of ATC procedures
- Flight procedures and system requirements for simultaneous IFR approaches to triple and quadruple parallel runways using existing and improved runway monitoring systems
- Technical reports on simulation results and risk analyses

H.2.7 Wake-Vortex Separation Standards Reduction (021-230)

Responsible Division: ARD-200
Contact Person: Cliff Hay, 202/267-3021

Purpose

To safely reduce separation standards by understanding wake-vortex strength, duration, and transport characteristics, especially the effects of vortices in the terminal environment. Reduction in separation standards will enhance airspace use, increase airport capacity, and decrease delays in instrument meteorological conditions (IMC).

Data from tower fly-by tests will be combined with new data to determine actual traffic spacing being used under visual flight rules (VFR) conditions. Vortex strength, decay, and transport characteristics, as well as the meteorological conditions that affect these characteristics, will be examined at selected airports. Flight test simulations will be designed and conducted to determine if reducing the separation standards currently being used under IFR conditions is feasible. Closely spaced parallel and converging runways and departure sequencing will also be studied through simulation. Existing aircraft weight classifications will be reviewed to determine whether the weight classifications and corresponding separations can be modified to improve single runway operations.

Program Milestones

In FY93, appropriate high traffic airports were selected for data collection for capacity analyses. Data will be analyzed in FY94 to develop new parallel runway separation criteria for FAA approval in FY95.

Work will continue on a joint effort with NASA to develop models and simulation techniques that characterize wake-vortex hazards. Flight tests will be conducted to validate the models and simulations. In parallel with these models and simulations, work will continue on developing algorithms to integrate sensor inputs and provide the information to ATC automation systems by the year 2000.

Products

- Feasibility report on reducing separation standards in the terminal area
- Recommendations on aircraft weight classifications
- Separation algorithms to TATCA based on leading/following aircraft types

H.2.8 Traffic Alert and Collision Avoidance System (TCAS) (022-110)

Responsible Division: ARD-200
Contact Person: Tom Williamson, 202/267-8465

Purpose

To develop, demonstrate, and assist in implementing an independent airborne collision avoidance capability to increase safety in the National Airspace System by reducing the potential for midair collisions and increase capacity by using the improved cockpit display capability for simultaneous approaches to parallel runways and pilot maintained in-trail spacing.

There are three TCAS versions, each with successively increasing capability. TCAS I generates traffic advisories to assist pilots in locating potential midair collision threats. TCAS I is under evaluation through a Limited Implementation Program (LIP) on several types of in-service commuter aircraft. This program will provide operational and performance data on commercial TCAS I equipment in actual service.

TCAS II equipment includes a Mode S transponder and is intended for installation in transport category and high performance general aviation aircraft. It provides traffic advisories and also compute vertical-plane resolution advisories that indicate the direction the aircraft should maneuver to avoid collisions. Resolution advisories between two aircraft are coordinated between aircraft using the integral Mode S transponder. TCAS II development and operational implementation have been completed. Federal Aviation Regulations require that all aircraft with more than 30 passenger seats operating in U.S. airspace be equipped with TCAS II by December 30, 1993.

TCAS IV equipment, intended for installation in transport category aircraft, is designed to generate traffic advisories and resolution advisories in both the horizontal and vertical planes. Maneuvers will be coordinated between similarly equipped aircraft. The FAA is supporting minimum operational performance standards (MOPS) development for TCAS IV by a RTCA special committee. The FAA has developed a plan to complete the remaining development and test efforts and evaluate the TCAS IV system on airline aircraft in a LIP.

Program Milestones

All 10 to 30 seat turbine-powered commuter aircraft must be equipped with TCAS I by February 9, 1995 in accordance with Federal Aviation Regulations. That same year, the FAA will continue a multi-year TCAS I transition program to assist aircraft operators with TCAS I implementation.

As mentioned above, all commercial turbine-powered aircraft with more than 30 passenger seats are required to be equipped with TCAS II in accordance with Federal Aviation Regulations. In 1995, the FAA will continue to work with the aviation community to resolve technical and operational issues associated with TCAS II implementation. Engineering support to develop logic modifications to reduce unnecessary alert rates will continue.

A LIP will be conducted to determine the certification and operational requirements for TCAS IV.

Products

- Reports on TCAS I avionics evaluation to provide guidance for TCAS I certification and operation
- Reports on TCAS II installation, certification, and operation on air carrier aircraft
- TCAS II transition program report documenting TCAS II implementation program results and required modifications
- TCAS II requirements document for TCAS II certification in transport category aircraft
- ICAO standards and recommended practices for international certification and operational approval of TCAS II
- RTCA MOPS for required performance of TCAS IV under standard operating conditions
- Study assessing the safety characteristics of TCAS IV
- Report on TCAS IV installation, certification, and operation in air carrier aircraft

H.2.9 Vertical Flight Program (022-140)

Responsible Division: ARD-30
Contact Person: Richard A. Weiss, 202/267-8759

Purpose

To improve the safety and efficiency of vertical flight (VF) operations and increase NAS capacity through RE&D into air traffic rules and operational procedures, heliport/vertiport design and planning, aircraft/aircrew certification training, and applications of emerging technology.

Program Milestones

The Rotorcraft Master Plan (RMP) envisions advanced VF technologies providing scheduled short-haul passenger and cargo service for up to 10 percent of projected domestic air travel. To accomplish this expanded use of vertical flight, the FAA is responsible for developing the appropriate infrastructure and regulations in parallel with industry's actions and commitment to develop and operate market-responsive aircraft.

The VF program is being executed through many concurrent projects and activities, which are divided into three technical sub-program areas: Air Infrastructure, Ground Infrastructure, and Aircraft/Aircrew.

The Air Infrastructure sub-program will provide RE&D to enable safe, reliable, all-weather operations for VF passenger and cargo aircraft. The research results will include: developing non-precision and precision GPS terminal instrument approach and departure procedures; more compatible IFR approach and departure angles; improvements in low altitude navigation and air traffic control services using GPS, data link and SATCOM technologies; VF air route design; and noise abatement procedures.

Ground Infrastructure research will address heliport and vertiport design and planning issues, including the terminal area facilities and ground-based support systems that will be needed to implement safe, all-weather, 24-hour flight operations. Developing obstacle avoidance capabilities is a critical design-related effort. Research will include applying lessons learned from detailed accident and rotorcraft operations analyses. Simulations will be used extensively to collect data, analyze scenarios, and provide training to facilitate safe operations.

Aircraft/Aircrew research will develop minimum performance criteria for visual scenes and motion-base simulators; evaluate state-of-the-art flight performance for cockpit design technology; develop improved training techniques employing expert decision making, and develop crew and aircraft performance standards for determination of display and control integration requirements. Research will also be conducted in support of the FAA's responsibilities to certificate both conventional and advanced technology VF aircraft.

Products

- Helicopter non-precision and precision GPS approach terminal instrument procedures criteria
- ATC route standards, procedures and models
- Vertiport/heliport design standards
- Improved VF noise planning tools
- VF noise abatement procedures
- Rotorcraft simulator standards
- VF aircrew training and certification requirements
- Cost/benefit assessments for deploying advanced VF technologies

Schedule

- Produced audio visual training aids and workbooks to assist in training in expert decision making techniques — FY94
- Published delay reduction analysis for a Northeast Corridor civil tiltrotor-based short-haul transportation system — FY94
- Delivered night vision enhancement device operations and training materials — FY95
- Publish advanced technology VF performance and demonstration guidelines — FY95
- Publish results of test and analysis of a variety of heliport and vertiport design parameters, including minimum required VFR airspace for curved approaches and departures, minimum parking and maneuvering areas, marking and lighting, and rotorwash protection requirements — FY96
- Conduct extensive VF noise data collection from operational profiles — FY96
- Publish Technical Report supporting certification requirements of VF aircraft display formats — FY96
- Publish national-level guidelines for joint industry and local government advanced technology VF demonstration program — FY96

- Develop low noise conversion corridor criteria for rotorcraft FY97
- Publish terminal area IFR procedures for steep-angle approaches and departures FY97
- Publish simulation-based analysis of pilot performance in an obstacle-rich environment, with results being used to evaluate necessary heliport and vertiport design criteria FY97
- Publish advanced technology rotorcraft noise certification recommendations FY98

H.2.10 Flight Operations and Air Traffic Management Integration (022-150)

Responsible Division: ARD-100
Contact Person: Bill Blake, 202/267-7264

Purpose

To develop the capability to integrate aircraft flight management systems (FMS) with ground-based air traffic management (ATM) automation via data link to increase airspace capacity and ensure more efficient flight operations along more flexible conflict-free route trajectories.

An important factor in ATM and FMS integration is developing automated communications between aircraft FMS and ground ATM computers. This will be accomplished by developing a set of flight operations and air traffic management integration (FTMI)-specific data link operational requirements. FTMI operational concepts will be developed and validated via simulation experiments coupled with aviation community-supported flight trials.

This project will establish the operational requirements for flight operations procedures and standards fully utilizing existing FMS capabilities in the near-term to enhance system capacity and flight efficiency in oceanic, en route, and terminal airspace. This analysis will lead to standards for nationwide FMS-guided terminal operations by analyzing requirements for FMS-guided curved approaches to and departures from selected airports.

A standard set of functional and operational requirements to support the next generation ATM-compatible FMS will be developed. This effort will integrate existing and planned capabilities of the ATM system and the FMS/ flight deck.

In addition to enhanced ATM and FMS integration, this project will explore the benefits of including the aeronautical operation control (AOC) component of the fight operations system to the integrated ATM/FMS. The information exchanged between AOC and ATM could provide fuel savings, more efficient use of airspace, and reduce delays.

Program Milestones

In FY93, an analysis to support flight standards for developing FMS-guided curved approaches at Minneapolis-Saint Paul International Airport (MSP) was completed. Continued analyses to support development of flight standards and procedures for both FMS-guided approaches and departures at selected airports will be completed in FY95. Nationwide FMS-guided terminal operations standards are expected in FY97.

Simulation experiments involving route maneuvering in oceanic airspace to demonstrate FMS capabilities in improving flight efficiency in oceanic airspace will be conducted in FY94 and FY95. Flight trials will be conducted with commercial airlines to validate procedures generated as a result of these simulations. Analysis of simulation experiments and flight trials is expected to result in flight standards by the year 2000.

Efforts will continue in FY95 to develop a functional and operational requirements document for advanced FMS capabilities to ensure full integration of flight management and ATM operations.

Products

- Data to support flight operations procedures and standards for FMS-guided operations in terminal, domestic en route, and oceanic airspace and on the airport surface. Candidate ATM procedures to support FMS-ATM-AOC integration via data link
- Integrated FMS-ATM automation system operational concept document
- New FMS-ATM system capabilities document
- FMS-ATM automation interface requirements document
- FMS-ATM integration requirements document
- Revisions to two-way data link clearance data dictionary

H.2.11 Separation Standards (023-120)

Responsible Division: ARD-100
Contact Person: Carl Bowlen, 202/267-7047

Purpose

To provide quantitative guidance for domestic and international efforts to establish minimum safe horizontal and vertical separation standards.

Tests will be conducted to provide quantitative guidance based on statistical analysis to support decision-making to reduce vertical and horizontal (lateral and longitudinal) separation requirements. This activity consists of model development, data collection, data reduction, and analysis and includes: (1) the investigation of the effect on separation standards of imposing tighter required navigational performance specifications, (2) determination of the effect of tolerating mixtures in the total aircraft population of both old and new specifications, and (3) investigations of the potential for the safe improvement of separation requirements in a system with advanced future navigation, communications, and air traffic management systems. This effort will also help establish separation requirements based on Automatic Dependent Surveillance (ADS), Area Navigation (RNAV), and other developing technologies for supporting reduced permissible separation minima.

The oceanic horizontal separation standards program will analyze separation standards in the North Atlantic, West Atlantic, Central East Pacific, and North Pacific route systems. It will examine the impact of various system improvements on safe minimal lateral and longitudinal spacings for oceanic traffic. As oceanic control becomes increasingly flexible through improved communications and enhanced automation, this program will establish appropriate separation standards to improve system efficiency while maintaining and acceptable level of safety.

Onboard, time-based navigation capabilities and associated ATC procedures will be analyzed to determine the effects of changing from a distance to a time-based longitudinal separation standard.

The vertical separation program has determined the feasibility of reducing the vertical separation minimum between FL290 and FL410 from 2,000 to 1,000 feet, thus adding six additional flight levels in this altitude range. Efforts in this area are aimed at implementing RNAV initially in the North Atlantic and then the Pacific. Full implementation in NAS is scheduled for January 1998. This change will provide the ATC system with enhanced flexibility to accommodate user-preferred flight profiles and will lead to substantial savings in user fuel costs.

Program Milestones

In FY90, the ICAO guidance material for world-wide and regional reduction of the high-altitude vertical separation standard from 2,000 to 1,000 feet was finalized and approved.

In FY91 the national guidance material amending current Pacific track longitudinal separation standards was completed. This amendment resulted in application of a 10-minute separation minimum.

In FY93, agreement was reached for implementation of a reduced vertical separation minimum in NAS minimum navigation performance specification (MNPS) airspace with operational trials commencing January 1, 1997. Beginning in the spring of 1995, height-keeping performance will be evaluated to ensure compliance with published altimetry and altitude keeping performance.

In FY94-95, ICAO guidance material for separation standards in the horizontal plane will continue to be developed. The four major items are area navigation (RNAV), Required Navigation Performance (RNP), Automatic Dependent Surveillance (ADS), and General Guidance on Separation Standards for Airspace Planners. The goal is to complete RNAV guidance in 1994-1995. The RNP was requested by the ICAO Future Air Navigation Systems (FANS) committee and has implications for the world-wide use of global positioning system (GPS) and establishing separation standards. The RNP guidance material for en route of types was approved in 1993. The introduction of ADS will provide near real time surveillance and communications in many areas that presently depend on pilot reports over high frequency communications. A new methodology is being developed to provide quantitative guidance for establishing separation standards reflecting new technologies. These new technologies include ADS, satellite-based navigation, enhanced communications, and advances in the air traffic management system. This effort is expected to be completed in 1995-1996. The final major effort is the continued work on developing general guidance on separation standards for airspace planners. This effort is expected to be completed in FY96.

Products

Horizontal Separation Standards

- Reports on the feasibility of reduced horizontal separation in oceanic airspace

- Reports on simulation and test results for reduced horizontal oceanic separations
- Data packages for international coordination of horizontal oceanic separation standards
- Requirements for implementation of reduced horizontal oceanic separation standards

Vertical Separation Standards

- Data analysis and operational tests and evaluation of reduced vertical separation
- Support for rulemaking on vertical separation standards
- Input to ICAO documents
- Support for implementation of reduced vertical separation minimums in Pacific airspace
- Monitoring of height keeping performance with implementation of reduced vertical separation minimums in North Atlantic MNPS airspace

H.2.12 Aviation System Capacity Planning (024-110)

Responsible Division:	ASC-100/200
Contact Persons:	Jim McMahon, 202/267-7425 Nick Johnson, 202/267-9817

Purpose

To establish a forum, sponsored and supported by the FAA, in which airport management, local FAA, airline, commuter, and industry groups, and airport planning consultants work together to develop technically feasible alternatives for improving airport and airspace capacity and reducing delay.

Capacity design team studies have been established at various airports where the need for capacity improvement has been identified. The studies typically investigate application of new air traffic control procedures, navigation aids, system installations, airport development, and other prospective capacity improvements. Alternatives are then evaluated using state-of-the-art computer simulations. The simulations provide a measure of the potential benefits of these improvement alternatives in terms of hours of delay reduction and allow the FAA to refine modeling techniques while gaining operational benefits through assistance to the capacity design team studies.

Program Milestones

The *1993 Aviation System Capacity Plan* was produced, analyzing the benefits of new airport development, airspace changes, new technology, and progress in implementing improved air traffic control procedures to support airport, airspace, and procedures improvements. In addition, final reports for airport capacity design team studies at Albuquerque, Boston-Logan, Cleveland, Port Columbus, Eastern Virginia (Richmond, Norfolk, and Newport News/Williamsburg), Fort Lauderdale-Hollywood, Houston Intercontinental, Indianapolis, and Minneapolis-Saint Paul were issued. Airport capacity design team studies are underway at Dallas-Fort Worth, Las Vegas, and Portland. A terminal airspace study was completed for San Bernardino International Aiport. Airspace design teams for New York (Phase II), Jacksonville, Atlanta, and Miami/San Juan were completed in FY93 and final reports were issued in FY94.

In FY94, tactical initiatives will be underway for New York's LaGuardia Airport, Orlando International Airport, and Los Angeles International Airport. In addition, terminal airspace studies are underway for Philadelphia, Salt Lake City, and Tampa. A terminal airspace study is also planned for San Antonio. Regional design studies are planned for the San Francisco Bay Area, the Los Angeles Basin, and the New York Metropolitan Area. Airport capacity design team updates are underway for Seattle-Tacoma International Airport and Hartsfield Atlanta International Airport. .

From 1995 to 1998, simulations and flight demonstrations will be conducted to determine if the use of TCAS can be expanded to provide separation assistance.

Products

- Aviation System Capacity Plans
- Airport Capacity Design Team Reports
- Airspace Analysis Technical Reports
- Aviation Capacity Enhancement Action Plans
- Near- and long-term capacity enhancement report

H.2.13 National Simulation Capability (NSC) (025-110)

Responsible Division: AOR-20
Contact Person: Randall J. Stevens, 202/287-8504

Purpose

To establish the NSC to assess proposed subsystems, aviation procedures, airspace organization, and human factors in an integrated fashion to determine the definition of the 21st century NAS.

The NSC provides a means of analyzing and experimenting with alternative concepts for potential NAS development, as well as a capability for hands-on development of prototype configurations for future NAS integration. This enables improved assessment of new concepts, high-level system design, new technologies, system requirements, and potential problems and issues. Resulting requirements specifications for procuring NAS equipment will be more accurate, complete, and achievable.

Program Milestones

NSC began an active experimentation program in March 1992 at the Integration and Interaction Laboratory (I-Lab) at MITRE in Mclean, Virginia. During the balance of FY92, an active experimentation program was conducted, examining alternatives for interaction between traffic flow management and controller automation aids in the en route and terminal airspace. This initial phase of experiments concluded at the end of FY93. Also in FY93, a series of visualization exercises was conducted in support of initiatives from the FAA's Office of System Capacity and Requirements (ASC) to expand the use of TCAS as a separation assistance tool. Two exercises were run, one for closely-spaced parallel approaches into San Francisco International Airport and another to demonstrate an in-trail climb procedure proposed by United Air Lines. In FY94, a new series of experiments and visualization exercises will be conducted, examining integration issues associated with the time-phased implementation of AERA with CTAS, Traffic Flow Management (TFM), data link, and advanced weather products.

NSC began an active experimentation in November 1992 at the FAA Technical Center, using resources from both the Human Factors Laboratory and the Oceanic Development Facility. In FY93, experiments were run assessing alternative oceanic traffic control procedures needed for the introduction of new reduced vertical separation minimums in the North Atlantic. This work was completed in early FY94. Additionally in FY94, experimentation will be conducted exploring expansion of the in-trail climb procedure and in dynamic aircraft route planning in oceanic airspace.

Products

- Operational NSC experimentation capability to support assessments of interactions and inter-operations between ATC automation elements and aircraft and assessments of human performance in those systems
- Simulation results from alternative configurations of proposed future systems and procedures

H.2.14 Operational Traffic Flow Planning (025-120)

Responsible Division: AOR-200
Contact Person: Mark Salanski, 202/287-8526

Purpose

To provide near-term improvements in national level traffic flow management and influence the development of future traffic management systems.

The Operational Traffic Flow Planning (OTFP) program has the following goals:

- Quickly prototype decision support tools to supplement the expertise of the traffic flow management specialists of the Air Traffic Control System Command Center (ATCSCC).
- Develop strategies to resolve demand-capacity imbalances — using advanced operations research techniques and computer modeling.
- Analyze ATCSCC policies and procedures to ensure they benefit National Airspace System (NAS) users.
- Coordinate research efforts with other FAA programs to enhance nationwide operational traffic management.

The OTFP program is organized around a flexible plan for improving traffic flow management. It is designed so that developers can routinely make program adjustments based on changing operational concepts or advances in technologies. All project efforts are organized to quickly supplement the experience of national traffic management specialists and improve the selection of traffic flow management strategies.

OTFP research projects are organized into the following coordinated framework:

Strategy Development Tools

The OTFP system will generate optimal strategies for current or anticipated NAS conditions. It will provide the TFM specialist with one or more efficient strategies to consider. Models being developed for this program include the High Altitude Route System (HARS), Planned Arrival and Departure System (PADS), Knowledge-Based Flow Planning (SMARTFLOW), and Optimized Flow Planning (OPTIFLOW).

Demand Assessment Tools

Tools that access and analyze TFM information. Tools include Daily Decision Analysis System (DDAS) and the Flight Simulation Monitor (FSM). DDAS enables the ATCSCC to anticipate route and schedule changes made by the airlines and then examine associated capacity impacts. FSM enables air traffic managers to visualize the airlines' flight cancellations and substitutions.

Performance Measurement Tools

Tools that evaluate proposed flow management strategies and resolve demand/capacity imbalances in the NAS include the Daily Flow Simulation Model (FLOWSIM) and the NAS Simulation Model (NASSIM). FLOWSIM models traffic between all major U.S. airports up to 24 hours in advance. NASSIM analyzes the resource-limited throughput in the NAS and graphically presents this data.

Capacity Assessment Tools

These systems enable the ATCSCC to estimate NAS resource use and workload. The Critical Sector Detector (CSD), being developed by OTFP, determines which (if any) en route airspace sectors might reach controller workload saturation in the near future.

Policies and Procedures Research

These research efforts help traffic management specialists in the ATCSCC enact policies and procedures that affect all users of the NAS. The primary OTFP effort which could affect FAA policies and procedures research is the FAA-Airline Data Exchange (FADE). FADE seeks to evaluate how up-to-the-minute airline schedules affect traffic flow management decisions. OTFP researchers are assessing the viability of dynamically exchanging data with the airlines and assessing if updated demand information can influence air traffic management decision making, specifically in regards to ground delay programs.

TFM Decision Support Tool Testbed

OTFP tools are linked to a common data source to allow accurate modeling and analysis of the NAS or any of its components. The Continental U.S. National Airspace Data Access Tool (CONDAT) consolidates and translates data from several diverse and often inconsistent sources into a single standardized repository.

Program Milestones

In FY94, the HARS capabilities were expanded to include enhanced communications software for FAA/ airline interactive planning. Also accomplished in FY94: a demonstration/ evaluation of PADS was completed; the FLOWSIM field prototype was developed; the CONDAT prototype demonstration and testing was completed; the initial NASSIM prototype testbed was developed; development, demonstration, and testing were completed for the SMARTFLO field prototype; and the FSM, the ground delay program substitution visualizer, was implemented as a field prototype.

HARS - Field prototype development will continue in order to provide follow-on enhancements to enable full track generation and traffic optimization for high altitude traffic anywhere within the United States. It will also develop the integration necessary to provide interoperability with national and oceanic traffic management systems. In 1995, ADS and data link system interfaces will be developed to provide real-time communications between ATCSCC and the full range of airspace users. This effort will complete HARS development and the resulting technologies will migrate into OPTIFLOW.

PADS - This functional prototype, scheduled for ATCSCC testing in 1995, will provide a real-time ability to develop airport departure and arrival scheduling plans that optimize daily traffic flows for long-range flights between major city-pairs. The field prototype development and demonstration is planned for 1995-1996. Delivery of the PADS field prototype in 1996 will enable ATCSCC and traffic management units (TMUs) to interactively plan with commercial aviation dispatchers to develop optimized high altitude flight sequencing in conjunction with the HARS and OAS traffic models.

OPTIFLOW - Operations research for this model will be completed in 1995. The initial prototype testbed demonstration and ATCSCC evaluation will begin in 1995. The field prototype development will follow in 1996 with field prototype demonstration and evaluation planned for late 1996 and early 1997. Field prototype delivery is planned for 1997.

FLOWSIM - The integration of this model with other tools will be completed in 1995.

CONDAT - Development and integration of this model will continue through 1997.

NASSIM - Operations research for predicting and simulating detailed daily traffic and flow strategies will continue in 1995. This model will use and integrate many technologies and tools developed for other projects (HARS, PADS, FLOWSIM, and OPTIFLOW). The initial prototype demonstration and evaluation is planned for 1995. Follow-on field prototype development is planned for 1995-1996 with field prototype demonstration and evaluation scheduled to begin in 1997. Field prototype delivery to ATCSCC and TMUs is planned for late 1997.

SMARTFLO - Delivery of this model to ATCSCC is scheduled for 1995.

DDAS - Testbed prototype development for dynamic, digital data exchange of scheduling information between the ATCSCC and airline scheduling facilities will continue in 1995. Prototype demonstration and testing is scheduled for 1995. Integration with other OTFP projects will follow in 1995-1997.

FSM - Prototype development will be completed in 1995. ATCSCC analysis and integration will continue for planned fielding in 1995-1997.

Products

Demand Assessment Tools

- Daily Decision Analysis System (DDAS) for automation tools to quickly analyze airline schedule change impacts
- Ground Delay Program Substitution Visualizer (GSUBV) to demonstrate the TFM effects of airline substitution practices
- Flight Simulation Monitor (FSM) to examine in real time which airplanes are being moved in response to a ground delay program

Performance Assessment Tools

- Daily Flow Simulation Model (FLOWSIM) for fast-time national pacer airport traffic flow simulation
- NAS Simulation Model (NASSIM) for detailed NAS-wide traffic prediction and simulation

Strategy Development Tools

- High Altitude Route System (HARS) for optimized fuel-efficient jet routes
- Planned arrival and departure system (PADS) for developing optimal departure and arrival scheduling plans
- Knowledge-Based Flow Planning (SMARTFLO) for quick response flow advisories to expert systems
- Optimized Flow Planning (OPTIFLOW) for dynamic national traffic flow optimization

TFM Decision Support Tool Testbed

- Continental U.S. National Data Access Tool (CONDAT) to provide a common data source for all OTFP simulation and optimization efforts
- OTFP System to integrate functions of the individual project initiatives

Policies and Procedures Research

- FAA/Airline Data Exchange (FADE) to evaluate how up-to-the-minute airline schedules affect traffic flow management decisions

H.2.15 Air Traffic Models and Evaluation Tools (025-130)

Responsible Division: AOR-200
Contact Person: Steve Bradford, 202/287-8519

Purpose

To produce modeling and analytic tools to support operational improvements, airspace and airport design, environmental analysis, investment decision-making, and ATC system design analysis.

The tools developed by this project will provide ATC with the ability to rapidly plan, evaluate, and update operational changes to accommodate the more dynamic airport/airspace environment. These models will respond to the dynamic changes resulting from satellite navigation and increased ATC and cockpit automation. This program will emphasize improvements to existing models and new model development. Modeling products will be improved to make them simpler, faster, more effective, and more widely used and accepted.

Development will focus on integrated airport and airspace modeling. Previously developed models, such as the National Airspace System Performance Analysis Capability (NASPAC) and SIMMOD, will be made easier, faster, and more flexible to use. The Sector Design Analysis Tool (SDAT) is used in redesigning en route airspace to increase capacity and balance controller workload. SDAT derivatives are the terminal airspace sector design analysis tool (T-SDAT) and the regional airspace sector design analysis tool (R-SDAT). These will provide new capabilities for evaluating terminal and multi-center en route airspace design. Another analytical tool, the critical sector detector (CSD), will be developed to determine when airspace sectors will reach critical traffic density levels based on controller workload limits.

Program Milestones

In FY94, SIMMOD capabilities were established in an ARTCC, a TRACON, and an FAA regional office. Also, new SIMMOD logic is being developed to increase simulated traffic dynamic control and account for en route system dislocations. In 1995, SIMMOD capabilities will be established at additional FAA regions and en route centers. In 1996, a new version (SIMMOD Version 3) will be released to accommodate future airspace requirements for user-preferred direct routing.

In FY94, R-SDAT was developed. R-SDAT implementation is expected in 1995. T-SDAT testing will be conducted in 1995, with completion/implementation scheduled for 1997. Work will continue in 1995 on CSD development with completion/implementation scheduled for 1996.

In 1995, work will continue on developing a user-friendly workstation production version of NASPAC. The current version of NASPAC is a prototype developed by the MITRE Corporation that considers various performance measures for determining NAS-wide impacts from proposed system improvements. The production model will permit analysts to conduct studies more easily and quickly, and will provide more sensitivity to proposed changes in the overall airspace system design. In 1995, an initial NASPAC production model will be released. NASPAC testing will be conducted at the FAA Technical Center through 1996, with implementation expected in 1997.

Products

- Enhanced SIMMOD airport and airspace simulation model
- SIMMOD capability installed in ARTCCs, TRACONs, and FAA regional offices
- NASPAC U.S. airspace simulation production model
- SDAT, T-SDAT, and R-SDAT
- Critical sector detector (CSD)

H.2.16 Airway Facilities Future Technologies (026-110)

Responsible Division: ANS-300
Contact Person: Brenda Boone, 202/267-7313

Purpose

To develop the concept of operations, methods, policies, standards, organizational structures, and functions, validate them in a near-operational testbed environment, and prepare an orderly transition strategy to achieve the new Airway Facilities (AF) infrastructure needed to support the future National Airspace System (NAS). This will be accomplished through the development and use of simulation models and distributed and dedicated test facilities for assessing alternative operational and support concepts and methodologies.

The traditional AF role is changing dramatically as a result of new technology, a changing work force, and increasing levels of automated management of AF systems. The AF RE&D Plan is intended to focus individual projects, activities, and related applied research toward the common goal of realizing acquisition readiness for the AF infrastructure by the year 2000. The plan will specify the guidelines for determining the AF operational, organizational, functional, and technological baselines as well as analyzing their mutual interdependencies. The plan will also specify a program implementation process to ensure that RE&D in each of the areas is integrated and that the products lead to an integrated overall system to meet AF's future needs.

Models will be developed through rapid prototyping to evaluate promising operational concepts. Proposed procedures and operational concepts will be tested in simulated operational environments and scenarios. Alternative organizational structures will be developed and modeled for assessment and refinement. Evaluation tools will be provided to measure the correlation among operational concepts, organizational structures, functional capabilities, and technological capabilities.

This project will develop a testbed to investigate various scenarios associated with new technologies such as remote maintenance monitoring, the Operational Control Center, and AF interfaces with satellite systems. Expert diagnostic, predictive, and resolution tools (EDPRTs) will be developed to support preventative maintenance and to help isolate and solve equipment problems. The testbeds will be used to develop requirements and design approaches for the EDPRT tools and to investigate their use in simulated operational environments. Applications for an intelligent tutoring system (ITS) will be identified to provide additional interactive tools to increase AF productivity. These tools will be fully integrated with the EDPRTs.

By defining and developing alternative concepts of operations and then testing them in a near-operational environment using models, tools, and specialized tests, including actual systems and equipment, this project will achieve a validated operations and support concept. This validated concept will enable the project to develop an orderly transition strategy to move AF incrementally from today's traditional approach to an integrated, centralized AF infrastructure fully supportive of the NAS.

Program Milestones

In FY94, a technology assessment to identify key technologies applicable to AF operations was completed. In 1995, work will continue on developing the AF testbed. In 1996, testbed requirements will be complete, leading to an Operational Control Center prototype and GPS software interface in 1998. Analysis results should be available in 1997 and 1998 for developing policies, procedures, and standards.

In 1995, work on integrated modeling tools will be initiated to identify organizational alternatives and to simulate future AF system responsibility/functions in the NAS. These simulation models should be completed in 1996. Work will begin on organizational structure analysis tools in 1996 with completion planned for 1997. The models and tools will be used in 1996-1997 to develop, evaluate, and validate AF strategies, concepts, and methodologies for modernization within the NAS. The models will also be used to measure performance for allocating procedures and technologies used in systems management. Promising concepts and methodologies will be evaluated. The concepts and methodologies will undergo final validation in 1998 via field testing at selected locations. AF operational standards will then be developed.

Development will begin on the ITS and the EDPRTs in 1996. Prototypes will be completed in 1998 with operational systems available in 1999. Additional ITS/EDPRT development needs will be identified as new technology becomes available.

Products

- AF research program plan
- AF system testbed
- Expert diagnostic, predictive, and resolution tools
- Intelligent tutoring systems
- Validated concept of operations, methods, policies, standards, organizational structures, and functions
- AF transition strategy
- Integrated management information system performance requirements

H.2.17 Terminal Radar (ASR) Replacement Program

Responsible Division: ANR-200
Contact Person: Gerald Taylor, 202/606-4622

Purpose

To provide economical radar service at airports with air traffic densities high enough to justify the service and upgrade the highest density airports with the latest state-of-the-art equipment.

ASR-4/5/6 radars need to be replaced because of the decreasing availability of spare parts and the high-maintenance workload. Furthermore, repair parts for the ASR-4/5/6 radars are in short supply. A total of 96 ASR-4/5/6 radars are being replaced. Of these, 40 ASR-4/5/6 sites are being upgraded to ASR-9's, 40 ASR-4/5/6's are being upgraded to ASR-8's, and 16 ASR-4/5/6's are being upgraded to ASR-7's, a procedure called "leapfrogging."

Program Milestones

The first ASR-9 Operational Readiness Demonstration (ORD) was in FY90 and the first leapfrog ORD was in FY91. The last leapfrog ORD is scheduled for FY96, and the last ASR-9 ORD is planned for FY96.

Products

- Procure 134 radars
- Replace 96 radars
- Leapfrog 56 radars

H.2.18 Los Angeles Basin Consolidation

Responsible Division: ANS-300
Contact Persons: Jonathan Dorfman, 202/267-8680
John McCartney, 310/297-8680

Purpose

To consolidate five Los Angeles Basin Terminal Radar Approach Control Facilities (TRACONs) to be known as the Southern California TRACON. This new facility will enhance traffic management in Southern California and allow more efficient use of the airspace.

The Los Angeles Basin is created by the Pacific Ocean and the San Rafael, Sierra Madre, Techachapi, San Gabriel, San Bernardino, San Jacinto, and Santa Ana Mountain ranges. The basin area is approximately 75 miles wide and 100 miles long. The major portion of this airspace below 10,000 feet is currently controlled by TRACON facilities located at Los Angeles, Burbank, El Toro (coast), Ontario, and San Diego. These five TRACON facilities provide instrument flight rule services for 29 airports within their respective areas of jurisdiction. This includes eight major air carrier airports and five military airfields. Instrument operations in Southern California have increased greatly over the last two years. Forecasts call for well over 3,000,000 operations by the year 2000.

Products

This consolidation will enhance safety, improve airspace utilization, and provide an IFR air traffic control system approach for the major hub and satellite reliever airports in Southern California.

- Start site adaptation 01/90
- Building contract award (completed) 09/91
- Building occupancy date 02/93
- Los Angeles TRACON consolidated 02/94
- Coast TRACON consolidated 05/94
- Burbank TRACON consolidated 10/94
- Ontario TRACON consolidated 04/95
- San Diego TRACON consolidated 09/95
- Project completed 02/96

H.2.19 Traffic Management System (TMS)

Responsible Division: ANA-600
Contact Person: William L. Umbaugh, 202/287-2708

Purpose

To upgrade the present flow control system into an integrated Traffic Management System (TMS) which operates at the national level through the Air Traffic Control System Command Center (ATCSCC) and the local level through traffic management units (TMUs).

The upgrading of the traffic management system is designed to improve air traffic system efficiency, minimize delays, expand services, and be more responsive to user requirements. The TMS functions include various flow management programs with integrated metering functions such as the Departure Sequencing Program (DSP), En route Spacing Program (ESP), and the Arrival Sequencing Program (ASP) and Enhanced TMS (ETMS) functions such as the Aircraft Situation Display (ASD) and Monitor Alert (MA).

Program Milestones

Phase II has provided the Enhanced Traffic Management System, which is a computer network that implements the aircraft situation display (ASD) and monitor alert (MA) functions developed by the Advanced Traffic Management System (ATMS) research and development program, for the Air Traffic Control System Command Center (ATCSCC), all Air Route Traffic Control Centers (ARTCCs), and several Terminal Radar Approach Control Centers (TRACONs). New computer systems with color graphics workstations have also been provided to the ATCSCC, TMUs, and the FAA Technical Center, which interface with the Traffic Management Computer Complex (TMCC), the host computers, and the ETMS computers to provide enhanced information displays and near real-time flight data. The Arrival Sequencing Program (ASP) and En Route Spacing Program (ESP) Package 1 metering enhancements to the host computers have also been provided.

Follow-on activities to Phase II will include providing automation equipment to non-en route facilities, relocating the ETMS computers from the development location to an FAA facility, providing an enhanced high data rate interface between the Host and ETMS computers, integrating DSP into the TMS and providing meter list display capabilities for the ARTCCs. Other activities will include implementing ATMS functions on the ETMS, providing TMS hardware and software in the Advanced Automation System time frame until the next generation TMS becomes operational, and improving traffic management performance analysis capabilities by developing standards, procedures, and tools to facilitate the accurate reporting, collection, and analysis of NAS data.

Products

- The TMS computer complex is located at the FAA Technical Center. ETMS computers are currently located at the John A. Volpe National Transportation Systems Center, Cambridge, Massachusetts.
- Computer program suitable for adaptation and use at 20 domestic ARTCCs and selected TRACONs.

H.2.20 LORAN-C Systems

Responsible Division: ANN-300
Contact Person: Charles B. Ochoa, 202/267-6601

Purpose

To conduct necessary procurement and implementation projects to meet FAA responsibilities for the use of LORAN-C in the NAS.

LORAN-C is the government's navigation aid for coastal areas of the United States, including southwestern Alaska. Signal coverage was increased in 1991 over the mid-continent area and now all 48 contiguous states have LORAN-C service. Low-cost avionics have made LORAN-C an attractive area navigation aid for general aviation; it has been approved for en route and non-precision approach use under instrument conditions. One goal remains: to bring LORAN-C into maximum use in the NAS as a supplemental aid by completion of the installation of signal monitors to support non-precision approaches throughout the NAS. The signal monitors will provide the seasonal time difference correction information required to accurately perform a non-precision approach.

Program Milestones

Two new LORAN-C chains of stations were completed in the U.S. mid-continent in April 1991. LORAN-C monitor units consist of two parts: monitors and interface electronics to VOR equipment. Signal monitors were installed at 196 sites. Installation will be completed in 1994 when interface electronics are placed in the host facilities.

Products

- LORAN-C Signal Monitor System
- LORAN-C mid-continent transmitters

H.2.21 Automatic Dependent Surveillance (ADS)

Responsible Division: ARD-30
Contact Person: Jim McDaniel, 202/267-9870

Purpose

To support the development and implementation of an Automatic Dependent Surveillance (ADS) function to improve safety and provide economic benefits to users of oceanic airspace, as well as to aid oceanic controllers in effectively controlling oceanic airspace, with evolutionary applications to domestic airspace.

The ADS function will provide for improvements in tactical and strategic control of aircraft. Automated processing and analysis of position reports will result in nearly real-time monitoring of aircraft movement. The capability of ADS to provide timely and high-integrity aircraft position data via a satellite air/ground link will permit possible reduction in separation standards, as well as increase accommodation of user-preferred routes and trajectories.

The program will be developed in conjunction with the Oceanic Data Link (ODL) capability, which will add two way digital data communications for air traffic command and control.

Program Milestones

Implementation of ADS will be at the Oakland and New York Centers only. Oakland Center is scheduled for April 1996.

Products

- ADS mod operational at Oceanic Development Facility (ODF)
- Perform engineering/HF trials
- Complete avionics development support standards
- Develop international ADS standards and operational procedures (SOPS)
- Develop minimum operational performance standards (MOPS)
- ADS installed at Oakland and New York Centers

H.2.22 Automated En Route Air Traffic Control (AERA)

Responsible Division: AAP-200
Contact Person: Gary Rowland, 202/376-6559

Purpose

To provide an interactive software capability within the en route ATC automation system that is more accommodating to the routing preferences of the airspace users.

Specifically, AERA will provide the capability to: (1) permit most aircraft on IFR flight plans to fly user-preferred direct routes and altitude profiles, which will result in time and fuel savings, (2) increase the safety of the system by reducing the potential for operational errors, (3) increase system capacity by integrating en route metering with local and national flow control, and (4) increase controller productivity by increasing the number of control services that a control team can safely manage.

AERA, when fully integrated into the en route automation system evolving from the Initial Sector Suite System (ISSS), was planned for implementation in two steps, Introductory AERA Services (IAS) and Full AERA Services (FAS). IAS was envisaged as an interim step for ease of transition, risk reduction, and early provision of benefits. IAS uses the four-dimensional flight path trajectory modeling to support the following features:

- Flight plan conflict probe ,which will predict potential violations of separation standards between aircraft and between aircraft and special use (e.g., restricted) airspace
- Sector workload analysis, which will calculate and display personnel workload measures to supervisors and specialists to assist them in balancing sector staffing levels
- Trial flight plan function, which will allow controllers to evaluate alternative clearances prior to issuing them to aircraft
- Automated reconformance, which will adjust the calculated trajectory to reflect the aircraft's actual flight path and notify the controller of each adjustment in order to maintain system safety
- Automated replan, which will aid the controller in granting conflict-free user requests at the earliest possible time

Approximately one year after the implementation of the integrated IAS, the remaining FAS capabilities will be implemented. These extend IAS from detecting potential conflicts to providing the controller with suggested resolutions. The automation generated resolutions will avoid the predicted conflict, not cause additional conflicts and minimize the deviation from the aircraft's preferred route.

In 1993, a plan for Early AERA was generated. The objectives of Early AERA are to:

- Take advantage of emerging AAS technology to introduce AERA to sector controllers earlier than possible with the fully integrated IAS/FAS implementation approach
- Implement with minimum impact on ISSS development schedule and cost
- Reduce the risk to implementation of IAS and FAS
- Provide benefits to airspace users earlier than otherwise possible

Each AERA development package will undergo a series of rigorous engineering and validation steps consisting of algorithmic development, operational suitability evaluations, computer performance functional specification generation, software design and development, and comprehensive operational test and evaluation.

Program Milestones

Functional specifications for the AERA 1 functions were completed in FY84. AERA 1 research and development was completed in early FY85. Modifications to the original AERA 1 functionality were made in FY92 to transform AERA 1 into Introductory AERA Services (IAS). IAS development, operational evaluation, and implementation will be accomplished as part of the AAS contract.

AERA 2 functional specifications were completed in FY86. Prototype laboratory evaluations were completed in FY90, and detailed algorithmic and computer/human interaction specifications were produced.

AERA 2 design and analysis began in FY90 as part of the AAS contract. In FY92, activities were adjusted to accommodate the revised approach to Full AERA Services implementation. AERA 2's automated problem resolution capability and supporting functions will continue to be designed and developed as part of the AAS contract in coordination with IAS development. This software will undergo operational evaluations in ATC laboratory simulations. After operational suitability has been demonstrated, the software will be finalized and implemented.

From December 1991 through November 1992: (1) AAS specifications were revised to reflect the new approach to Full AERA Services implementation; (2) AERA design activities under the revised implementation approach continued and algorithmic and computer-human interface risk reduction demonstrations were conducted; (3) analysis of the extendibility of the detailed

ACCC design to IAS was completed, as well as preliminary extendibility analysis to FAS.

In 1993 and early 1994, a high-level strategic plan was generated for an Early AERA functionality and procurement approach. Meetings were held with the AERA team to generate operational concepts for providing AERA benefits early , and an early AERA core requirements review was conducted. Planning meetings for integrating AERA and other new systems into the post-ISSS en route system have been initiated.

Products

- AERA will provide key en route traffic conditions and prediction data to the Traffic Management System (TMS). The upgraded traffic management system will be integrated with AERA to keep both short- and long term traffic planning coordinated
- The AAS ACCC step has been replanned to include IAS and FAS incremental development, as well as Early AERA benefits
- Weather products provided by the Center Weather Processor (CWP) will be used by AERA. More accurate wind data will improve AERA performance
- Aeronautical Data-Link, interfaced through AAS, will provide automated controller/pilot data and advisory interchange

H.3 Communications, Navigation, and Surveillance

H.3.1 Aeronautical Data Link Communications and Applications (031-110)

Responsible Division: ARD-60
Contact Person: Ron Jones, 202/287-7088

Purpose

To develop and validate domestic and international data communications standards and data link services associated with the Aeronautical Telecommunications Network (ATN) as well as special purpose air/ground data link capabilities.

To provide the technical framework for all NAS systems that plan to implement data link services and applications.

Communications

Communications standards for aviation use will be developed, validated, and standardized. Domestic standards are being developed with the Radio Technical Commission for Aeronautics (RTCA) and international standards with ICAO. ATN standards are currently being validated with industry participation.

Extended use of the Mode S Squitter for delivering GPS-based aircraft position reports will be investigated. This automatic dependent surveillance (ADS) concept will provide a technology that will support airport surface traffic automation (ASTA) in developing an airport surface surveillance system. Also, this technology will serve as a basis for future cockpit traffic information systems.

Applications

Data link services in oceanic, en route, terminal, and tower environments are being defined through a coordinated effort between the air traffic and aviation user communities and will be developed and evaluated by a team made up of air traffic controllers, pilots, and other system users. Demonstrations will be conducted with both ground and airborne system users to validate overall operational system effectiveness.

Operational and procedural benefits of data link applications will be verified using full-fidelity airborne and ground simulation facilities. The tower ATC services will be evaluated at selected airports in a fully operational environment with participating air carriers. Routine and hazardous weather applications will be demonstrated and evaluated in various simulation and airborne testbed facilities. Weather and aeronautical services such as traffic advisories, digital automatic terminal information service (ATIS), and ADS-Mode S Squitter applications will also be validated using this approach.

Program Milestones

In FY94, ATN internetwork communications standards were completed, computer-generated voice and digital ATIS was developed, and RTCA flight information services minimal operational performance standards (MOPS) were completed.

Operational procedures development will continue for ATC air/ground data link applications in the en route, terminal, and tower environments in 1995. First operations for initial terminal ATC data link services are planned for 1996-1997. Operations for initial en route data link services are planned for 1997-1998.

ICAO standards and recommended practices for Mode-S data link and ATN will be published in 1997 for the initial ATN. RE&D activities will continue through 1999 to support development and validation of standards that extend the ATN for international operations and management. ATN research, through a cooperative flight test program sponsored by FAA and industry, will validate ATN standards and will provide ATN operating experience. This will be completed in 1997.

Initial weather and aeronautical data link functions will be deployed in 1996. As a result, functional specifications will be completed in 1997 for the next generation aeronautical and weather data link services, with implementation targeted for the year 2000.

Development efforts will continue on surface/air surveillance applications that use ADS techniques based on GPS aircraft position information. These applications will use Mode-S Squitter for delivering this data to airport surface and terminal surveillance systems. Demonstrations are planned for 1995.

Products

- U.S. and international ATN data communications and applications standards
- Specifications for production automation and communication systems that use/support data link
- Prototype systems to support operational data link service evaluations
- Demonstration test beds for developing advanced weather, flight information, and ATC services
- Testbed for ATN development, evaluation, and validation

H.3.2 Satellite Communications Program (031-120)

Responsible Division: ARD-60
Contact Person: Dennis Weed, 202/287-7091

Purpose

To develop the standards and perform the required testing to support mobile satellite communications (SATCOM) operational use for civil aviation, beginning with oceanic, offshore, and remote regions.

To extend this capability to enhance NAS communications and surveillance functions.

Developing Satellite Communications Data Capabilities for Oceanic and Remote Regions

The FAA will support RTCA Special Committee 165 to develop minimum operational performance standards (MOPS) and ICAO standards and recommended practices (SARPs) for frequency coordination. SARPs validation will be performed using simulation, analysis, testing, and demonstration. A ground test facility will be developed to conduct system end-to-end and radio frequency (RF) tests to validate standards not currently validated by manufacturers' data. Flight tests will be performed to evaluate state-of-the-art equipment and system enhancements. Aeronautical mobile satellite service (AMSS) testing will be conducted with industry and FAA developed equipment. Simulation will be used to evaluate the planned architecture performance.

Developing Satellite Communications Voice Capabilities for Oceanic and Remote Regions

This initiative will provide satellite voice capability between the cockpit and the Air Route Traffic Control Center (ARTCC) in oceanic flight information regions. A guidance document will be produced, in conjunction with RTCA, describing the full range of technical requirements to provide satellite voice capability. An architecture will be developed that will enable controllers to send and receive direct satellite voice communications. Flight trials will be conducted with major airlines to demonstrate and evaluate satellite voice capabilities.

Implementing Satellite Communications Services in Oceanic and Remote Regions

Technical expertise, analyses, and data will be provided to the Communications/Surveillance Operational Implementation Team (C/SOIT) to develop operational regulations and procedures that implement satellite communications. The benefits derived from SATCOM require a combined effort among ATN, ADS, ARTCC automation, and SATCOM. Technical data will be collected from bilateral and multilateral engineering trials. This initiative will integrate real-time end-to-end communications and communication capabilities into the Oceanic Development Facility.

Developing Satellite Communications Services for Selected Domestic Applications

The currently defined oceanic aeronautical mobile satellite service (AMSS) system may have applications in domestic areas such as offshore or mountainous regions where very high frequency (VHF) does not penetrate. It may also be possible to use Low Earth Orbiting or Medium Earth Orbiting systems to provide reliable and efficient data/voice capability that meets domestic requirements at a reasonable cost. This project will conduct feasibility studies and evaluations on lower cost, light-weight satellite communications avionics for general aviation and rotorcraft.

Program Milestones

In FY94, ICAO AMSS SARPs were developed and validated, engineering trials for satellite communications voice capabilities in oceanic and remote regions were conducted, communications/surveillance operational implementation team plan was published, and requirements definition on alternative SATCOM technologies for domestic applications were completed.

Verification of ICAO AMSS MOPS and SARPs will be completed in 1998 for SARPs compliance certification and ICAO approval. RTCA guidance documentation on SATCOM voice avionics will be published in 1995. Architecture provisions based on this documentation will be completed in 1996 for ground interface with FAA equipment. Data collection will continue through 1995 from Pacific and Atlantic engineering trials. This data will be provided to the C/SOIT for regulatory and procedural implementation guidance. The feasibility of lower cost, light-weight SATCOM avionics for general aviation and rotorcraft will be determined in 1996. In 1995, research will be initiated on long term alternatives for providing SATCOM service in domestic areas with planned completion in 1999.

Products

- International aeronautical mobile satellite service (AMSS) standards and recommended practices (SARPS) with ICAO
- Minimum operational performance standards (MOPS) for AMSS with the Radio Technical Commission for Aeronautics (RTCA)
- AMSS voice communications architecture

H.3.3 NAS Telecommunications for the 21st Century (031-130)

Responsible Division: ASE-200
Contact Person: Cindy Peak, 202/287-8621

Purpose

To develop the next generation NAS communications system by evaluating alternatives in new communication technology to satisfy future operational NAS requirements and goals.

The current priority of this project is to improve the air/ground communications system to accommodate the increasing traffic load for the 21st century. Competition for additional frequency spectrum is intense and will constrain internationally allocated VHF frequencies. Expanding VHF system capacity will require new VHF radios for both the FAA and user communities.

The overall objectives of this project are to focus RE&D funding on leveraging new technology, reducing communication system cost, and adhering to a disciplined systems engineering approach.

New technologies will be explored to quantify their performance in meeting NAS capacity and reliability requirements. Key factors include using commercial equipment whenever possible, streamlining operations, developing a transition plan, and integrating with other NAS elements. A cost/benefit study will be completed for each potential technology and a tradeoff analysis among alternatives will be performed.

Accommodating evolving national and international communication standards and applying global addressing, routing, and network management technologies will be incorporated into design of the system. System requirements, operational concepts, system design, and appropriate standards will be developed for an air/ground digital voice and data communication system. Technology transfer efforts will be initiated to facilitate industry participation in system development. System elements will be thoroughly prototyped and tested.

Program Milestones

In FY94, a prototype radio system was developed and flight tested. A U.S. position on VHF spectrum utilization for ICAO was developed. Procurement specifications will be prepared in 1995 to support a request for proposal in 1996 with a contract award expected in 1997. Initial installation of the new system is expected to begin in 1998.

Products

- Internationally compatible requirements and standards for a new VHF air/ground communication system
- Operational concept document for the new communication system
- New VHF communication system design specifications
- New VHF communication system prototype, including flight demonstrations
- Request for proposal for system procurement

H.3.4 Satellite Navigation Program (032-110)

Responsible Division: ARD-70
Contact Person: Joe Dorfler, 202/267-7219

Purpose

To develop augmentations to satellite navigation systems, such as the Global Positioning System (GPS), to support procedures, and standards for oceanic, en route, terminal, non-precision approach, precision approach, and airport surface navigation using a single set of required avionics in order to improve safety, capacity, service flexibility, and operating costs.

The initial focus of this program has been to develop standards and methods to use GPS without augmentation as a supplemental aid to meet civil aviation requirements down to non-precision approach. The next phase includes investigating GPS augmented for Required Navigation Performance (RNP), an internationally defined measure of a navigation system's performance within a defined airspace, for en route, airport surface, departure, and precision approach applications, including curved and missed approach guidance. GPS augmented for RNP will constitute a "stand-alone" configuration with required redundancy.

A satellite navigation testbed will be established at the FAA Technical Center to verify theoretical analyses, collect data in a realistic environment, simulate "worst case" scenarios, and provide a means to analyze performance data.

Program Milestones

In FY93, Technical Standard Order (TSO) C-129 for GPS avionics used as a supplemental means of navigation for oceanic and domestic en route, terminal, and non-precision approach flight phases was developed. The FAA Flight Standards and Certification Services authorized the use of C-129 GPS receivers for flight phases down to non-precision approach, other than for localizer-based approaches. In FY94, the first non-precision instrument approach procedure based on GPS Terminal Instrument Procedures (TERPS) criteria was developed. Also in FY94, Minimum Aviation System Performance Standards (MASPS) for Special Category (SCAT) I approaches using local-area differential GPS were published. It is expected that, by the end of FY94, Minimum Operational Performance Standards (MOPS) for GPS avionics augmented for RNP with Long-Range Navigation-C (LORAN-C) and the GPS Wide-Area Augmentation System (WAAS) will be completed. A functional specification for the WAAS was developed, which will support precision approaches throughout the CONUS about 1998. A navigation testbed developed at the FAA Technical Center demonstrated WAAS capability through cross-country flights using WAAS integrity and differential correction information relayed through an International Maritime Satellite (INMARSAT) 2 satellite.

In FY95, MOPS for GPS augmented for RNP using Global Navigation Satellite System (GNSS) and inertial systems will be completed. Demonstrations using GPS for oceanic, domestic en route, and terminal operations and for non-precision and precision approaches will continue. These demonstrations will support the development of standards and operational procedures to permit expanded use of satellite navigation for civil aviation. Research on GPS CAT II/III approach feasibility will be completed by 1995. This research will be used to support the evaluation of candidate navigation architectures for the future NAS.

GPS augmented for RNP is expected to be implemented in oceanic airspace in 1995 and in domestic en route airspace through non-precision approach by 2000. GPS supplemented precision approaches to CAT I will be approved for private use in 1994/1995 and for public use in 1998.

Products

- Satellite-based instrument approach procedures
- MOPS and a TSO for avionics to support use of GPS as a supplemental means in the NAS
- MOPS and TSOs for avionics to meet RNP in the NAS
- Augmentation requirements for GPS to meet civil aviation RNP
- MASPS for SCAT I instrument approaches

H.3.5 Navigation Systems Development (032-120)

Responsible Division: ASE-300
Contact Person: Dave Olsen, 202/287-8763

Purpose

To identify and evaluate technologies and new concepts for future radio-navigation systems and to develop requirements for a smooth transition into satellite-based navigation.

The emphasis of this project is to support the development of a NAS transition strategy that will provide guidance for a major shift to satellite technology. The project will focus on resolving current navigation system supportability, the transition to satellite-based navigation, and potential phase-out of ground-based systems. This project also supports the Federal Radio-Navigation Plan (FRP) biennial revision and provides input to the joint Department of Transportation (DOT) and Department of Defense (DOD) Positioning & Navigation (POS/NAV) Group.

Research will continue on current ground-based system supportability issues until a transition to satellite technology is completed. Potential operating cost reductions, performance enhancements, or new functional additions to navigation aids now operated by the FAA will be identified. The potential to enhance navigation aids will be examined and available technology will be identified. Algorithms for enhancements will be developed and applied in laboratory simulations to test their effectiveness. One example of this is improving the VOR antenna system to reduce sensitivity to the site environments.

Studies and analyses will be performed to support completion of the concept of Required Navigation Performance (RNP) for final approach and landing operations. The results from these efforts will be used to develop recommendations on the RNP criteria. The recommendations will be provided to the ICAO All Weather Operations Panel (AWOP), the Satellite Operational Implementation Team (SOIT), and RTCA, Inc. special committees for incorporation into appropriate standards.

Studies and analyses will be performed to support the FRP. Based on research results, recommendations will be made on the appropriate system mix to be included in the FRP. A national aviation standard will then be prepared and maintained for each system approved for use in the NAS.

Program Milestones

In FY94, an intitial capability was developed to issue NOTAMS on GPS satelite outages. Further work is underway to develop airport specific GPS NOTAMS. The 1994 Federal Radio-Navigation Plan will be published in December 1994. Support to the development of a NAS transition strategy will continue, and a recommended strategy will be provided in 1995.

National aviation standards for the GPS/LORAN-C and GPS Integrity Broadcast/Wide Area Augmentation System (GIB/WAAS) will be developed in 1996. These standards will be used by manufacturers to develop Technical Standard Order approved equipment. Research on current navigation system supportability for VOR, NDB, and TACAN will be completed in 1995, leading to a recommendation on replacement system procurement.

Work will begin on developing the next edition of the Federal Radio-Navigation Plan in 1995. A final GPS NOTAM capability will be implemented in 1997 to support GPS RNP requirements.

Products

- Support development of a NAS transition strategy
- Reports on enhancing performance and reducing costs of existing ground navigation systems
- GPS notice to airmen (NOTAM) capability
- National aviation standards for radio-navigation systems
- Recommendation for the NAS system mix
- Biennial FRP publication

H.3.6 Terminal Area Surveillance System (033-110)

Responsible Division: ARD-90
Contact Person: Jim Rogers, 202/267-9077

Purpose

To develop the next generation terminal area surveillance system (TASS) by defining system requirements, determining future operational concepts, assessing emerging technology applicability, benefits, and risks, and developing advanced capabilities in weather and aircraft detection and weather prediction.

More timely and accurate aircraft and weather detection capabilities will reduce system delays and separation criteria. The next generation TASS will be able to detect dry microbursts at useful ranges; measure wind fields from which wake vortex predictions can be made; detect ice, water, hail, and tornadoes; and support aircraft surveillance operations with seamless coverage and flexible routing tailored to the specific terminal site.

Operations research analysis techniques will be used to assess and identify practical airspace safety and capacity enhancing features in emerging technology. New terminal surveillance sensors will use a modular architecture to provide for site adaptation and upgrade at minimal cost. One option analyzed may be to combine primary surveillance radar and hazardous/non-hazardous weather detection in a single high data rate multi-function radar. For all options analyzed, the potential cost savings will be balanced against the additional program risk that may be incurred. Demonstration experiments will be conducted to reduce the potential risk of future development. The results from these experiments will lead to multiple selections for prototype development and testing.

Program Milestones

In FY94, TASS operational requirements were defined and a simulation program established to quantify benefits and reduce technical risks. TASS alternative analyses will be completed in FY95, and contracts will be awarded for demonstration/validation (DEMVAL) of selected designs. The DEMVAL phase will be completed in FY99, and a contract will be awarded for full-scale development of the best design. A production contract is planned for FY02.

Products

- Operational requirements and design concepts
- Technical requirements feasibility assessments
- Full-scale development prototype
- Production contract

H.4 Weather

H.4.1 Aviation Weather Analysis and Forecasting (041-110)

Responsible Division: ARD-80
Contact Person: Ken Klasinski, 202/287-7081

Purpose

To participate in interagency activities to better understand aviation weather phenomena such as icing forecasts; en route and transition turbulence, ceiling, and visibility; thunderstorm and microburst prediction; wind analysis and forecasting; and oceanic weather observation, analysis, and forecasting.

To develop models and algorithms for generating nowcast and short-term aviation specific products.

To develop and test computer-aided training modules for the users of newly developed forecasting methods and products.

The U.S. Weather Research Program (USWRP) is a congressionally-mandated interagency program under the lead of the National Oceanic and Atmospheric Administration (NOAA). The FAA will participate in the USWRP to address regional and local scale weather phenomena that are unique to aviation.

The major objective for icing forecasting improvements is to develop an aircraft structural icing forecast capability that will provide accurate delineation of actual and expected icing areas by location, altitude, duration, and potential severity. Added capabilities include the ability to forecast the onset, intensity, and cessation of structural icing on the ground to support deicing activities.

The major objective for detecting and avoiding clear air turbulence will be to develop a model for short-term en route and transition turbulence forecasting using wind, temperature, and moisture data. A variety of models will be developed and applied to forecasting wind flow patterns, downbursts, wind direction changes, wind shear, and gust fronts for the lower atmosphere.

This research is being coordinated with and accomplished through an interagency agreement with the National Science Foundation, National Center for Atmospheric Research, and universities. Prototype products developed through the Aviation Weather Analysis and Forecasting Project will be tested and evaluated by the Aviation Weather Development Laboratory (AWDL) at Boulder, Colorado and the Experimental Forecast Facility (EFF) at Kansas City, Missouri.

Program Milestones

In FY94 winter icing forecasting techniques were field tested at Denver ARTCC.

Field testing and demonstrations on winter icing forecasting techniques for the Chicago and east coast ARTCCs will be accomplished in 1996 and 1998, respectively. Denver test results will undergo analysis at the Aviation Weather Development Laboratory in 1995, Chicago results in 1997, and east coast results in 1999. Improvements in icing forecasts will continue in 2000 using high resolution humidity data available from the airborne humidity sensor being developed by the Airborne Meteorological Sensors Project.

In 1995, research will continue on automating forecasted changes in ceiling and visibility at airports. This development will transition to the Integrated Terminal Weather System/Aviation Weather Products Generator in 1998. Further improvements will be developed between 1998 and 2000 using the high resolution humidity data from the airborne humidity sensor.

Products

- Precise and usable algorithms and/or numerical models related to icing, turbulence, convective initiation, visibility, ceiling, and snowstorm forecasting
- New mesoscale numerical data assimilation and prediction models adapted to aviation needs and new methods for nowcasting
- New prototype aviation weather products of AWDL and EFF test and evaluation
- Automated techniques for detecting, quantifying, and forecasting meteorological events

H.4.2 Airborne Meteorological Sensors (041-120)

Responsible Division: ARD-80
Contact Person: Ken Klasinski, 202/287-7081

Purpose

To develop specialized airborne meteorological sensors to provide three-dimensional basic meteorological data needed to create accurate icing, turbulence, and visibility forecast products to provide early hazardous weather warning in the terminal area and en route airspace.

This project will develop meteorological sensors to measure humidity and icing that can be carried aboard aircraft to provide near real-time three-dimensional weather data that is currently not available from remote sensors. The data obtained from these airborne sensors will automatically be transferred to FAA and the National Weather Service weather processing systems by the Meteorological Data Collection and Reporting System (MDCRS) operated by ARINC.

The technology developed will provide design guidelines and engineering data to support industry production and certification initiatives for airborne meteorological sensors. Aviation weather products that are developed as a result of these sensors will be provided to air carriers in the test and validation phase to validate the user requirements and encourage rapid deployment in the air carrier fleet. Prototype airborne sensors will be evaluated in conjunction with the operational testing of the Integrated Terminal Weather System and Aviation Weather Products Generator.

Research will be carried out to determine the most cost-effective approach for providing a turbulence index, or rather, an index that determines how various aircraft respond to turbulence encounters. Airframe motion estimates of turbulence must be corrected for airspeed, wing loading, and airframe type to give a universal turbulence index. Candidate designs will be tested in an aircraft and the resulting predictions compared with the results of turbulence encounters. Algorithms to estimate turbulence areas will be developed and tested operationally at the Integrated Terminal Weather System and Aviation Weather Products Generator prototype test sites.

Program Milestones

In FY94, a Request For Proposal (RFP) for a prototype humidity sensor and sensor flight certification was initiated. Also, turbulence index algorithms were developed. In 1995-1996, experimental humidity sensors will undergo flight test evaluation/demonstration and operational utility assessments. If these assessments suggest a significant cost-benefit from more rapid humidity profile updates, multiple off-the-shelf sensors will be recommended for procurement in 1997.

The turbulence index algorithm will be flight tested in 1995-1996 to determine the correlation between the index and aircraft performance. This algorithm will be passed on to air carriers in 1997 for implementation.

In 1998, work will begin on detecting icing aloft using both ground-based and airborne sensors.

Products

- Prototype humidity and icing sensors
- Certification of sensors that measure humidity and icing aboard air carrier aircraft
- Design guidelines, engineering data, and functional requirements for the sensors
- Turbulence index algorithms for using the sensor data to provide improved turbulence products
- Automated humidity and clear air turbulence reports downlinked from air carrier aircraft

H.4.3 Integrated Airborne Wind Shear Research (042-110)

Responsible Division: ARD-200
Contact Person: Cliff Hay, 202/267-3021

Purpose

To develop, test, and analyze systems that provide an improved operational capability to detect, monitor, and alert flight crews to wind shear hazards.

This project is divided into two areas. The first, airborne wind shear advanced technology, addresses the equipment certification issues. The second, wind shear training applications for Federal Aviation Regulations (FAR) Parts 91 and 135, addresses the training and flight crew certification issues.

Airborne Wind Shear Advanced Technology

This work will support the development of standards for airborne wind shear equipment and is being accomplished through a cooperative agreement with the National Aeronautics and Space Administration (NASA). The technology developed will provide design guidelines and engineering data to support industry production and certification initiatives for advanced wind shear warning systems and flight crew decision aids. The data will be provided to FAA certification, regulatory, and compliance offices. The technology will be transferred to manufacturers and operators to accelerate their development and certification programs resulting from FAR 121.358 requirements.

Flight tests will be conducted to evaluate onboard airborne wind shear sensor performance by flying the test aircraft into wind shear conditions. Additional flight tests will uplink and evaluate available ground products to support time-critical information processing and display in the cockpit. The ground-based ATC system will be supplied airborne-derived information via downlink.

Further research will investigate new applications for wind shear sensor technology with an integrated systems approach developed in the joint NASA/FAA wind shear program. Results from this research will be applied to clear air phenomena.

Wind Shear Training Applications for FAR Parts 91 and 135

The first task of this project will be to define the issues of implementing wind shear pilot certification in the field. This will combine all the FAR Parts 91, 135, and 121 products into a comprehensive set of documents. The next task will be to define pilot certification requirements for wind shear escape and recovery.

The overall wind shear training applications portion is being carried out in three phases. Phase 1 dealt with crew examination, Phase 2 is developing the four wind shear products, and Phase 3 will address wind shear training support issues.

Program Milestones

In FY94, mountain rotor hazard characterization and definition was completed. Also, Phase 3 of Wind Shear Training Applications for FAR Parts 91 and 135 was completed. This successfully concludes this research area.

Further research in airborne wind shear advanced technology will concentrate on three specific clear air phenomena: mountain rotor, clear air turbulence, and wake vortices. For all three areas, a method will be developed to characterize and measure the phenomena and then advanced sensor technology will be applied to detect and provide a hazard warning.

Mountain rotor research and flight tests will be completed in 1995 and sensor development is expected for 1996. Definition of wake vortices will continue in 1995, as will flight tests, with sensor development expected in 1997. Clear air turbulence research efforts will begin in 1996, with flight tests expected in 1997, and sensor development in 1999. A final demonstration of sensor capabilities will include a Category II low visibility approach for closely-spaced parallel runway operations. Advanced sensor development for low visibility surface operations will begin in 1997.

This project will integrate the output from airborne and ground-based systems to ensure the detection, warning, and avoidance of hazardous clear air phenomena. This integration will be accomplished in conjunction with air traffic control during the development cycle for the three major areas of research.

Products

- Recommendations based on study of wind shear effects on aircraft performance
- Atmospheric model for lowest 1,000 feet of the atmosphere
- Sensor technology assessments for microwave radar, coherent pulsed lidar, and passive infrared and sensor integration into the flight deck
- Wind shear hazard algorithm used with ground-to-air data link to provide information on the flight deck
- Operational requirements for airborne wind shear warnings

H.4.4 Integrated Terminal Weather System (ITWS)

Responsible Division: ARD-80
Contact Person: Ken Klasinski, 202/287-7081

Purpose

To develop a system that will integrate all the terminal weather sensors to provide near-term automated weather information and predictions in easily understood graphical form.

Air traffic controllers in tower cab and TRACON facilities rely on a number of terminal area weather sensors, which collectively provide large amounts of data. The interpretation of this data is performed manually and is labor intensive, and the data from the various sensors may be confusing. The need to interpret large amounts of confusing data interferes with normal air traffic control functions. However, the main shortcoming of the present system is that it cannot anticipate short-term weather changes that affect safety, capacity, and efficiency. Specifically the present system cannot accurately predict changes in weather elements, e.g., ceiling, visibility, wind shear, microbursts, and thunderstorms, and the impact of these changes on terminal area operations.

The ITWS is focused on providing safety and planning products to Air Traffic Control Specialists (ATCSs) from the current time out to about 30 minutes. It will collect all of the weather data available in the airport terminal area, from both ground-based and airborne sensors. These include Next Generation Weather Radar (NEXRAD), Terminal Doppler Weather Radar (TDWR), Automated Weather Observing System (AWOS)/Automated Surface Observation System (ASOS), Low-Level Wind Shear Alert System (LLWAS), and aircraft-reported data via the congressionally mandated Meteorological Data Collection and Reporting System (MDCRS). These products include wind shear and microburst warnings, storm cell information, lightning that may affect airport operations, terminal area winds aloft, runway winds, short-term ceiling and visibility predictions, and snowfall rate predictions to assist in ground de-icing decisions.

Program Milestones

The ITWS will be deployed at the 45 airports associated with the TDWR. Initial deployment of the ITWS will provide well-defined, beneficial products available as an initial systems capability, followed by enhancement packages when both the required input systems and algorithms become available. The ITWS is in the demonstration/validation phase. Demonstration sites are Orlando, Dallas-Fort Worth, and Memphis International Airports.

H.4.5 Aviation Weather Products Generator (AWPG)

Responsible Division: ARD-80
Contact Person: Ken Klasinski, 202/287-7081

Purpose

To produce high-resolution, accurate, and timely automated graphical predictions of weather variables that impact aviation, such as icing and turbulence, which will be easily understood by air traffic control specialists (ATCSs).

Accurate weather forecasts are not available in the en route domain of the National Airspace System (NAS) on a time scale comparable to that of other U.S. flights, i.e., 30 minutes to several hours. Current weather information systems can only report the present state of the weather and forecast future weather with very low resolution. National Weather Service (NWS) forecasts are based on 12-hourly observations spaced 200 miles apart across the U.S. With these observational limitations, the high-resolution forecasts needed by the aviation community are not available or possible. Continued manual analysis, such as that performed by NWS meteorologists to identify specific aviation weather impacts, e.g., icing and turbulence, cannot provide the product timeliness and resolution required to significantly reduce related delays. On a national scale, the poor forecast resolution and slow update frequency result in advisories that are ineffective due to broad overwarning. Also, the present system does not provide the graphical depiction of aviation weather impacts necessary to promote rapid assimilation by ATCSs.

The AWPG program will be a joint effort with the NWS and will capitalize on their new super-computing capabilities, the increased resolution of the national weather data base through new sensor systems such as NEXRAD and wind profilers, the development of models dealing with small-scale weather phenomenon that are of major importance to aviation, and the automatic conversion of the NWS computer generated weather data forecasts to weather information that impacts aviation. These efforts by the NWS will be made possible through the development of the Aviation Gridded Forecast System (AGFS), which will produce the automated prediction of weather variables that impact aviation.

The AWPG will receive weather forecast data from the NWS and generate specific weather observation, warning, and forecast products to ATCSs in Automated Flight Service Stations (AFSSs), Air Route Traffic Control Centers (ARTCCs), and the Air Route Traffic Control System Command Center (ATCSCC), without intervening meteorological interpretation. This capability will be made available to users via existing and planned NAS platforms, e.g., WARP.

The AWPG is divided into two components, an analysis and forecast component and a product generation component. The first component is the Aviation Gridded Forecast System (AGFS) that is being developed for the FAA by NOAA's Forecast Systems Laboratory. It will provide the numerical and statistical techniques to automatically generate a high-resolution analysis and forecast of aviation impact variables (AIVs), namely winds, temperature, icing, turbulence, cloud base height, visibility, hail, and convective precipitation. The AGFS will be incorporated into the NWS supercomputer software for operational generation of AIVs.

The second component, AWPG product generation software, is being developed to convert the AFGS into user-specific products for use by air traffic controllers. As new products are developed and tested, they will be incorporated into existing and planned NAS subsystems as preplanned product improvements.

The AWPG product generation development is being transferred to private industry. Use of Cooperative Research and Development Agreements with private weather service companies will be utilized throughout the product demonstration and validation period.

A vital input to the model generation of the AGFS is aircraft reported data via the congressionally mandated MDCRS.

Program Milestones

The AWPG is in the demonstration/validation phase. Demonstration sites include Minneapolis ARTCC, Fort Worth ARTCC, Fort Worth AFSS, Denver AFSS, and the ATCSCC.

H.5 Airport Technology

H.5.1 Airport Planning and Design Technology (051-110)

Responsible Division: ACD-100
Contact Person: Satish Agrawal, 609/485-6686

Purpose

To improve existing design standards pertaining to runways, taxiways, aprons, and gates and develop standards and advisory information to be used in planning and designing airports, terminals, and ground access systems.

Ever increasing travel demand and projected growth in traffic in the next 15 years will influence airport design, layout, and configuration, and require improved landside facilities. A major concern facing the U.S. air transportation industry is how to manage increases in air traffic with improved safety, reduced delays, and minimal operational constraints.

As advances in air traffic control and other airport improvements increase airside efficiency and capacity, passenger facility capacity and access to the airport will become a limiting factor. Optimum airport utilization will require that there be a smooth and uninterrupted flow of passengers, cargo, and airplanes between the various elements of the airport system.

The goal of this program is to eliminate runway acceptance rate as a limiting factor in maximizing airport capacity. This will be achieved by reducing the runway occupancy time as much as practical. It will also require optimizing the geometry of runway and taxiway exits which will allow aircraft to negotiate turns safely at higher speeds. Research will also be conducted to optimize existing airport facility designs to balance the relationships between access roads for public and private transportation and parking lots. Clearances and design requirements of future aircraft will be identified and the adequacy of current airport designs for those requirements will be reviewed. Simplified methods will be developed for determining terminal, curbside, and airside capacities.

Program Milestones

In FY94, an analysis on current airport designs for compatibility with new transport aircraft was completed. Also, an airport accessibility index tool was developed.

In 1995, an initial taxiway system design and flow rate evaluation for triple and quadruple parallel runways will continue and design standards will be completed. Design advisory circulars will be re-examined to determine how airports should be planned and designed to accommodate new unique aircraft configurations with larger wingspans. Standards for the Boeing 777 will be completed in 1995 and standards for future growth aircraft will be completed in 1997.

Planning guidance for ground access to airports and for terminal building design will be developed in 1995 and an airport financial performance review will be completed in 1996.

Products

- Technical data to support advisory material, regulations, and guidance used by industry and the FAA
- Computer programs and user guides for use by industry and the FAA airport community
- Design standards for terminals and parallel runway configurations
- Terminal design simulation guidance and models
- Aircraft/terminal compatibility analyses

H.5.2 Airport Pavement Technology (051-120)

Responsible Division: ACD-100
Contact Person: Satish Agrawal, 609/485-6686

Purpose

To reduce the massive costs of pavement expenditure by at least 10 percent by the year 2010 through a research program featuring: (1) pavement design and evaluation, (2) materials and construction methods, and (3) repairs and maintenance techniques.

There are approximately 650 million square yards of pavement at U.S. airports. Replacement value is expected to exceed $100 billion and there are limited practical possibilities for adding to or replacing major pavement systems. The Federal Government and the aviation community are spending approximately $2 billion annually on pavement as well as additional costs of delay resulting from operational interruptions due to construction and maintenance. A significant portion of the $2 billion is spent replacing, repaving, rehabilitating, repairing, and maintaining pavement surfaces. During this decade, an estimated $40.5 billion in federal and local funds will be required to provide a more efficient and integrated public-use airport system under the FAA's National Plan of Integrated Airport Systems (NPIAS). Of this total, about $17 billion will be spent on constructing, maintaining, and rehabilitating airport pavements. The majority of this money will be spent at the most heavily used airports carrying the largest aircraft.

Specific projects will be undertaken to develop an advanced method for pavement design that will reduce pavement design and construction costs, pavement failures, maintenance costs, pavement down time, and aircraft delay costs. Initially, a pavement design method based on layered elastic theory will support U.S. aircraft manufacturer efforts to introduce new and heavier aircraft. An internationally accepted basis for evaluating if airports can accommodate new aircraft will be provided. Methods for nighttime and cold weather construction will be developed and methods for pavement evaluation and failure prediction will be improved in order to extend pavement life by at least 20 percent.

Pavement Design and Evaluation

Research in pavement design and evaluation area will focus on developing an advanced pavement design method that can be applied to the design of both flexible and rigid pavements. Efforts will first be concentrated on completing the layered elastic design method followed by more rigorous design methods such as finite element analysis to accurately model material properties. As part of validation of the layered elastic theory, full-scale pavement testing will be required using a facility that can accommodate multi-wheel configurations simulating the newer aircraft. The facility will provide aircraft response and pavement performance characteristics accurately. Evaluation of aircraft response and pavement performance will also be initiated at major new airports by installing advanced instrumentation and sensor systems in runways and taxiways. Research will also be conducted to develop design criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in cold regions.

Pavement Materials and Construction

Research in this area will include: developing methods to specify and use new or improved materials as substitutes for the conventional materials used for pavement construction; identifying factors affecting the durability of airport pavements and development of criteria for efficient use of devices, construction materials, and construction techniques; performing evaluation of coal-tar mixes; using roller-compacted concrete as a construction technique; and using geotextiles and grid type materials for strengthening airport pavements.

A new program will be initiated for organizing long-term data collection on pavement performance modeled on the Strategic Highway Research Program. This new program will be known as the National Airport Pavement Registry and Demonstration Program and will annually identify significant new airport construction to determine life-cycle costs and other performance factors.

Pavement Maintenance and Repairs

Research efforts in this area will include: determining probable causes of significant distress and life-cycle cost of pavements and developing criteria and guidance to effectively use seal-coating materials for enhancing pavement longevity.

Special life-cycle cost studies on heavy concrete pavements at Dulles and Dallas-Fort Worth Airports will be carried out because these pavements are at the end of their design lives. Pavement sections that show significantly more or less distress than average will be identified and their condition related to the number of stress repetitions, subsurface conditions, and other factors. The results will be used to develop guidelines for concrete pavement average life span, life-cycle costs, and to support developing new design methodologies.

Program Milestones

In FY94, layered elastic theory development was completed and design specifications for the National Pavement Test Machine were completed.

In 1995, the ten-year runway data collection effort will continue at the new Denver Airport using the newly installed pavement sensors. These sensors will measure the pavement response to repeated heavy aircraft loading. The data collected will be used to validate pavement design theories. This data collection effort will be completed in 2002. Computer software development using the predictive design and analysis methodology will continue in 1995, resulting in a stress-strain graphic display in 1999. New tests for material characterization will be completed in 1998 and controlled experiments under various applied and environmental loading conditions will be formulated to assure the methodology's accuracy. Studies will be initiated on durability of asphalt mixes and improved shoulder designs.

In 1995, work will continue on collecting and analyzing data that relate pavement performance to FAA design and construction standards. This effort will result in a comprehensive airport pavement data base in 2001. Criteria and methods for design, evaluation, performance, and serviceability of pavements at airports in cold regions will be completed.

In 1995, studies on pavement life-cycle costs and the National Airport Pavement Registry and Demonstration Program will be completed. Also in that year, national pavement test machine development will be completed. Pavement design tools based on layered elastic analysis and/or finite element analysis will be completed in 1997.

Products

- Technical data for pavement design and design life, evaluation, materials, construction, maintenance, and repair
- Software and user guidelines for pavement design and analysis
- National pavement test capability
- Pavement design tool

H.5.3 Airport Safety Technology (051-130)

Responsible Division: ACD-100
Contact Person: Satish Agrawal, 609/485-6686

Purpose

To develop new technologies in four research areas: (1) safe and efficient aircraft operations on runway surfaces; (2) new emerging technologies in lighting, signing, and marking materials for improved visual control systems; (3) new materials, methods, and equipment to improve the capability and cost-effectiveness of airport rescue and firefighting services; and (4) materials, methods, and devices to control birds and wildlife in the airport environment.

Runway Surface Technology

The condition of the runway surface is a critical concern at airports. Snow, ice, water, and rubber deposits can result in slipperiness, causing aircraft to lose control during braking and making surface movements hazardous. In recent years, grooved runways to control surface water have greatly reduced hydroplaning. However, aircraft accidents from overshooting or veering off contaminated runways remain a problem.

During the last 11 years, there have been 130 accidents involving aircraft overruns and veeroffs. The accidents involved runway surfaces that were either dry or covered with water, ice, snow, or slush. The three major aircraft accidents during the last 10 years have focused national attention to the question of runway slipperiness and loss of control during landings and takeoffs.

The goals of this program are to eliminate runway slipperiness as a cause of accidents by the year 2000 and to stop all aircraft within the extent of the runway. To achieve this goal, extensive research, testing, and evaluation will be conducted to develop new techniques, materials, procedures, and equipment to efficiently remove ice, snow, and rubber deposits. Also, research will continue on developing methods to prevent ice and snow accumulation on airport surfaces. New materials and methods will be investigated to decelerate aircraft safely, should there be an overrun.

Visual Guidance

Safe and efficient airport ground operations, especially at night and under low visibility conditions, require that pilots and vehicle operators receive conspicuous and unambiguous information from lights, signs, and other markings. Improvements in these visual aids are

one of the key elements in the FAA's Runway Incursion Program.

During the past 15 years, there have been seven air transport surface collision events in the U.S. These accidents have brought into focus the need for providing visual guidance to aircraft in low visibility conditions.

The goal of this program area is to eliminate, by the year 1997, deficiencies in the visual guidance systems and procedures that may contribute to surface collision accidents. This goal would require research efforts in two general areas: visual guidance "control" technology to develop an automated system for aircraft movement on airport surfaces, and developing state-of-the-art light sources and applications. These will include fiber optics, laser sources, and holographic techniques. Technology will also be developed to evaluate new visual guidance systems and procedures, particularly during low visibility conditions, on a computer-based simulation system.

Rescue and Firefighting

The analysis of aircraft accidents involving external fuel fires has shown that, although external fire is effectively extinguished, secondary fires within the fuselage are difficult to control with existing equipment and procedures. Large amounts of smoke, toxic gases, and high temperature levels in the passenger cabin can cause delay in evacuation and pose severe safety hazards. Reductions in off-runway response times will be achieved by developing a new truck suspension system that improves traction in soft sand, wet, and uneven ground conditions.

The goal of this program area is to increase passenger survival rate in post-crash fires by providing a safe evacuation route through the aircraft cabin in a timely manner. This goal would require research and testing to develop firefighting systems that can effectively be used to control both external and internal cabin fires. Research will be conducted to reduce vehicle response times during nighttime and in low visibility conditions to develop new training techniques for rescue and firefighting personnel. Improvements in response times and proper equipment development are needed for operations in poor visibility conditions.

Improvements in soft terrain and off-road firefighting vehicle capabilities will be needed to cope with expanded airport runway configurations into the year 2000 and beyond. New methods, procedures, and firefighting chemicals will be developed for use with large capacity aircraft, double-decked aircraft, and/or aircraft made from advanced materials.

Chemicals used in firefighting training facilities are raising concerns about environmental damage. Research will investigate methods to maintain a high level of performance for firefighting services, while minimizing air pollution and ground water contamination.

Wildlife

The presence of wildlife at and near airports poses a potential threat to movements of aircraft and other ground vehicles. In spite of various control devices in use to keep birds away, over one thousand incidents of bird strikes are reported every year. Many more incidents are known to occur, but are not reported.

The goals of this program are to increase airport safety and decrease damage to aircraft by reducing bird strikes. These goals require research efforts in developing effective regional wildlife habitat management to minimize or eliminate sources of bird attraction at airports. Research will also be conducted to identify active and passive harassment techniques that can effectively control the presence of birds and other wildlife at airports. These techniques and methods will help airport owners and operators in complying with FAA airport certification regulations. Land use sighting compatibility guidance will be provided by researching relationships among birds, airports, and landfills.

Program Milestones

In FY94, installation standards for a plastic foam arrestor system were completed, a technical report on runway sand application rates was completed, technical data for developing U.S. runway stop-bar standards was provided, an advisory circular on minimum rescue and firefighting capabilities at general aviation airports was published, and the third report on wildlife harassment/ deterrent techniques for airports was also published. Specifications for a firefighting penetrating nozzle boom and standards for fire extinguishing agents to replace Halon 1211 were developed in FY94.

Runway Surface Technology

In 1995, standards will be issued on runway sand application rates. In 1996, research will be completed on microwave debonding on runway ice. Also, testing will be completed on innovative methods of ice removal, with a final report in 1997, leading to an advisory circular in 1998. In 1997, a universal performance specification will be completed for removing runway rubber deposits. Also, research will begin on advanced aircraft arresting systems for new generation transport aircraft. Standards for an advanced aircraft arresting system are expected to be issued in 2005.

Visual Guidance

In 1995, standards will be issued for improved airport pavement markings based on technical research into factors such as durability and visibility under dry or wet conditions. Visual simulator enhancements will be completed for testing new and improved lighting systems under all weather conditions. A study on automatic traffic control logic and procedures will be initiated in 1996. This study will lead to developing design standards for an automated taxiway guidance system in 1998. Advanced technology lighting sources will be investigated in 1996 to develop more efficient airport visual guidance systems. The most promising technologies will be integrated into enhanced lighting systems by the year 2000.

Rescue and Firefighting

In 1995, work will continue on evaluating a penetrating nozzle's ability to suppress aircraft cabin fires. A study will continue on identifying the most cost-effective technology to provide enhanced vision and location definition for rescue vehicles responding to emergencies under poor visibility conditions. Work will continue on providing fire truck crews with information for efficient rescue operations following a crash. Efforts will continue on evaluating the rescue firefighting standards against requirements to control and extinguish fires in aircraft containing composite material.

An evaluation will be initiated in 1995 for aircraft rescue and fire fighter training simulators. A study will begin on a generic, full-scale firefighting training facility that meets both environmental concerns and operational requirements. Based on this research, the current training advisory circular will be updated for a standardized, generic firefighting training simulator. This is expected for 1997.

In 1995, an evaluation will be initiated on developing post-crash fire protection requirements for advanced double-decker aircraft seating up to 1000 passengers. In 1997, the current fire protection advisory circular will be updated to include the new generation transport aircraft such as the Boeing 777. It is expected that the advisory circular will be updated in the year 2000 to include fire protection for aircraft in the 600 to 800 passenger capacity and in 2006 to include aircraft up to 1000 passengers.

In 1996, an advisory circular will be published to cover technologies that deal with firefighting procedures for advanced composite aircraft and structures. In 1996, an advisory circular will be published to cover technologies that improve response during poor visibility conditions for firefighting vehicles. Research will be conducted to evaluate soil stabilization methods to support airport rescue and firefighting vehicles.

Wildlife

The second regional airport habitat management study will continue in 1995. Research on a fourth wildlife harassment/deterrent technique and landfill study will continue. The first regional habitat study at Atlantic City will be completed in 1995, with a final report expected in 1996, and a Mid-Atlantic U.S. advisory circular expected in 1997. The third regional habitat study will begin in 1996. Final reports on the fourth and fifth wildlife harassment/deterrent techniques will be finished in 1995 and 1996 respectively. Regional habitat management studies will be initiated and completed at a rate of every two years until the ten regional studies are completed. These regional airport studies are expected to continue through 2008, with advisory circulars published one year after the final reports.

The primary thrust of the above research efforts is to identify and document the effectiveness and applicability of new wildlife habitat management and harassment/deterrent techniques for use on or near airports to mitigate bird or wildlife hazards. Knowledge of bird relationships to existing and new solid waste facilities will establish a sound scientific basis to evaluate potential bird attraction effects on or near airports.

Products

- Technical data supporting rules, regulations, and advisory circulars on runway surface maintenance
- Technical data and design criteria for lighting and marking systems for airports, heliports, and vertiports
- Technical data on tests and evaluation of firefighting agents, full-scale systems, and rapid response all-terrain firefighting vehicle
- Technical data and advisory circulars on wildlife habitat management, bird harassment techniques, and landfill studies

H.5.4 Low-Level Wind Shear Alert System (LLWAS)

Responsible Division: ANW-400
Contact Person: Steve Hodges, 202/267-7849

Purpose

To monitor winds in the terminal area and alert the pilot, through the air traffic controller, when hazardous wind shear conditions are detected, since these conditions occurring at low altitude in the terminal area are hazardous to aircraft encountering them during takeoff or final approach.

Program Milestones

The LLWAS program was initiated in early 1975. Among the sensors evaluated were pressure jump detectors, pulsed and CW Lasers, acoustic Doppler systems, pulsed Doppler radar, and arrays of anemometers. The last technique was selected as the most cost-effective approach. Doppler radar promised the best capability at the time, but the technology was not sufficiently mature and the cost and technical risks were high. Full-scale development began in 1976, resulting in the evaluation of LLWAS at six airports. Production was initiated in 1978, 110 LLWAS units are now operating.

The program to upgrade the systems began in 1985 and contracts were awarded in 1987. The upgrade provided new processors and significantly improved the algorithm which increased the probability of detection and reduced the false alarm rate. This program was completed in the spring of 1991.

The LLWAS-Network Expansion (LLWAS-NE) upgrade, planned for nine airports, will provide improved microburst detection and identification. It will also provide new displays for controllers and provide runway oriented wind shear information. The LLWAS-NE has been operationally tested and evaluated at Orlando International Airport, and, as a result of this testing, software errors are being corrected by the LLWAS-NE contractor. The new Denver International Airport LLWAS-NE was placed in operation February 1994 and will be officially commissioned when the new airport opens. The remaining LLWAS-NEs will be commissioned in 1996. The LLWAS-NE will provide an integrated wind shear alert when the system is collocated with a Terminal Doppler Weather Radar (TDWR).

Products

- One hundred and ten production systems, including spares, training, and documentation.

H.5.5 VORTAC Program

Responsible Division: ANN-300
Contact Person: Charles B. Ochoa, 202/267-6601

Purpose

To form a modern cost-effective national navigation network which provides required coverage through the replacement, relocation, conversion, and establishment of VORTAC, VOR/DME, and VHF Omnidirectional Range Test (VOT).

Very High Frequency Omnidirectional Ranges (VOR) with Distance Measuring Equipment (DME) or Tactical Air Navigation (TACAN) are en route air navigational and approach aids used by pilots to conduct safe and efficient flights and landings.

From FY82 through FY89, the FAA replaced 950 vacuum tube-type VOR and VORTAC systems with modern solid-state equipment. New Remote Maintenance Monitoring compatible DME systems will replace existing DME systems at 40 VOR/DME sites. The DME units removed from these sites will be redeployed to ILS sites. 76 tube-type VOTs have been replaced with solid-state equipment, and 35 new VOT facilities have been established. VOR/DME facilities are being relocated to accommodate route structure changes, real estate considerations, and site suitability. Conventional VORs are being converted to Doppler VORs to solve siting problems and to obtain required signal coverage. Operational requirements that arise in various geographic areas require the establishment of VHF navigational aid services. Provisions have been made to establish 70 VOR/DME sites including new VOR/DME equipment at non-Federal takeover locations. DME systems will be added at 47 sites equipped with VOR only.

Program Milestones

All vacuum tube-type VOR and VORTAC equipment has been replaced with solid-state equipment which has embedded remote monitoring and control capabilities. DME service will be provided at all VOR facilities. A revised network plan will be developed to redistribute VORs to meet operational requirements during the transition from a ground-based navigational system to a satellite-based system. Tube-type VOT equipment has been replaced with solid-state equipment. VOR/DME and VOT sites will be established to meet operational requirements.

In FY90, the VOR/DME contract was awarded, the VOR/DME system design review was completed, and the design qualification test for VOT was completed. Plans are to issue a DME-only contract during FY95. A contract to procure all required Doppler VOR conversion equipment is currently in place.

Products

- To date, 725 VORTACs, 145 VOR/DMEs, and 80 VORs have been replaced, 35 VOTs have been established, and 76 VOTs have been replaced.
- In the next ten years, the FAA plans to establish 70 VOR/DMEs, establish 40 DMEs at VORs, replace 47 DMEs at VORs, reinstall 47 DMEs at ILSs, and convert 94 VORs to DSB DVOR.

H.5.6 Microwave Landing System (MLS)

Responsible Division: ANN-200
Contact Person: Gary Skillicorn, 202/267-6675

Purpose

To develop and implement a new common civil/military precision approach and landing system that will meet the full range of user operational requirements well into the future.

MLS is currently the international standard replacement for the Instrument Landing System (ILS), and there are vendors in several countries that manufacture at least the Category I version of the MLS. There are also several manufacturers of the basic avionics sets. Some users are questioning the benefits of equipping with MLS, given possible alternatives of improvements in the ILS and the potential use of satellite-based systems for precision approaches. Other users are willing to equip with MLS to take advantage of its inherent advantages over ILS.

Program Milestones

In 1984, the FAA awarded a contract to Hazeltine Corporation for 178 MLSs. However, the contract was terminated in 1989, and only two systems were delivered. From 1988 to 1992, the FAA conducted a demonstration program to show the economic and operational benefits of MLS. Under this program, the estimated costs associated with various avionics configurations were also generated. In March 1992, a final report on the demonstration program was sent to Congress. All nine projects in the program are complete except the deployment of all Category I MLSs, the DME/P interrogator development, and the delivery of the combined MLS/GPS receiver.

The FAA currently has three contracts for MLS systems. The first contract is with Allied-Signal for the delivery of 26 Category I FAR Part 171 systems. Three of these MLSs were installed. The other two contracts are with Wilcox Corporation and Raytheon Corporation for the design, development, and testing of six first article Category II/III MLSs from each contractor.These two contracts were terminated in 1994. A recommendation on a replacement system for ILS is expected in 1995.

Products

- Category I MLSs (28)

H.5.7 Runway Visual Range (RVR) Systems

Responsible Division: ANN-400
Contact Person: Calvin Miles, 202/267-6038

Purpose

To establish and modernize existing Runway Visual Range (RVR) systems on qualifying Category I, II, III a/b ILS and MLS runways. RVRs support precision approach landing operations.

RVR equipment provides real-time measurement of visual range along the runway. The RVRs in the NAS utilize old technology and cannot be economically upgraded to satisfy the requirements of the NAS in the 1990s and beyond. A new generation RVR has been conceived to economically satisfy all future NAS operating and maintenance requirements.

Program Milestones

A contract has been awarded to procure 528 RVR systems. The RVR systems have completed all factory required testing. Production systems are scheduled for delivery in FY94-95.

Products

- 528 RVR systems with proper documentation

H.5.8 Visual NAVAID Systems

Responsible Division: ANN-300
Contact Person: Charles B. Ochoa, 202/267-6601

Purpose

To provide safety-related and safety enhancement visual NAVAID systems at airports.

The facilities to be provided are: medium intensity approach lighting system with runway alignment indicator lights (MALSR), runway-end identification lights (REIL), precision approach path indicator (PAPI), omnidirectional approach lighting system (ODALS), and standard 2,400 foot high intensity approach lighting system with sequenced flashers (Category II configuration) (ALSF-2).

This program also includes:

- The procurement of equipment for the replacement or establishment of remote radio control capabilities for visual aids that meet the operational requirements of air traffic control and remove complex manually activated coding methods. The new system will permit single-button control of each visual aid function.
- The replacement of the existing rigid approach lighting tower structures with lightweight, low-impact-resistant structures that collapse or break apart upon impact to reduce damage to an aircraft should it strike an approach light tower during departure or landing.
- The installation of threshold light bars to existing MALSR to provide a visual reference to the runway threshold to make the present system more effective in low-visibility conditions.
- The replacement of visual approach slope indicators (VASIs) with PAPIs to satisfy the ICAO recommendation for PAPIs at international runways and to satisfy Air Line Pilot Association (ALPA) and general aviation requests for PAPIs at all validated approaches.
- The accommodation of the installation of approach lighting systems at those runway locations where GPS approach procedures are planned to be initiated.

The programming and implementation of visual NAVAID projects are based on each of the nine FAA regions submitting qualified candidates and the review and validation of these requirements by the FAA Headquarters sponsoring organization within FAA funding guidelines.

In addition, the President's Task Force on aircrew complement recommended the installation of vertical guidance capability at all air carrier runways, and those locations not equipped with vertical guidance devices will receive priority consideration.

Products

- Current Capital Investment Plan (CIP) planning envisions the installation of 200 additional MALSRs, 300 REILs, 400 PAPIs, 200 ODALs, 20 ALSF-2s, and approximately 200 rigid approach lighting structure replacements in the FY94 and beyond time frame

H.5.9 Precision Runway Monitor (PRM) for Closely Spaced Parallel Runways

Responsible Division: ANR-300
Contact Person: Byron Johnson, 202/606-4644

Purpose

To assess and demonstrate the feasibility of applying Precision Runway Monitor (PRM) to increase the aircraft arrival rate at airports with closely-spaced parallel runways and develop the necessary equipment.

To develop the necessary equipment to apply PRM at airports with closely-spaced parallel runways.

An airport's capacity to handle arriving aircraft is limited by the number of runways that are usable at any one time. In instrument meteorological conditions (IMC), the number of usable runways depends on the spacing between the runways. Without PRM — an enhanced radar and an associated controller display — simultaneous (independent) approaches are only allowed if runways are spaced at least 4,300 feet apart. With PRM, the spacing required between closely spaced parallel runways is reduced to 3,400 feet. This change will allow more airports to conduct simultaneous independent approaches during inclement weather.

This project demonstrates the increases in an airport's arrival capacity that are possible with enhanced radar and controller displays. It will also produce a series of measurements on the effect of navigational accuracy, effect of the distance between the parallel runways, and response times of controllers, pilots, and aircraft. These measurements will also be useful for other similar applications such as runway spacings below 3,400 feet and triple and quadruple parallel runways.

Program Milestones

Two engineering models of secondary beacon radars were tested: an electronically scanned (E-scan) beacon radar capable of a 0.5 second update interval (compared with a 4.8 second update interval available from today's radars), and a system that uses Mode S monopulse processing on back-to-back beacon antennas mounted on a conventionally rotating ASR system, capable of a 2.4 second update interval. The demonstrations of both E-scan and Mode S, begun in 1989, used improved high resolution displays. Controller studies and flight test demonstrations were conducted in 1990.

In FY90-91, engineering models were successfully demonstrated in conducting independent IFR approaches to parallel runways spaced 3,400 feet apart. Simulations of independent parallel IFR approaches to runways spaced 3,000 feet apart using 1 mrad, 1 second update rate were conducted in FY91. Further research and development are underway for IFR approaches at spacings below 3,400 feet. Results are expected in the latter part of 1994.

Specifications have been incorporated into a limited production contract which was awarded for five E-Scan systems in March 1992.

Products

- Operational requirements definition
- Automatic blunder-detection algorithms
- Validated runway separation model
- Measured performance of displays, blunder-detection algorithms, and E-Scan and Mode S sensors
- Evaluation and procurement specification for production sensors or sensor modifications
- Operational procedures and guidelines

Appendix I

Glossary

AAC .... Advanced AERA Concepts
AAF .... Army Airfield
AAP .... Advanced Automation, FAA
AAS .... Advanced Automation System
ACARS .... ARINC Communications Addressing and Reporting System
ACCC .... Area Control Computer Complex
ACD .... Engineering, Research and Development Service, FAA
ACE .... Airport Capacity Enhancement
ACF .... Area Control Facility
ADR .... Automated Demand Resolution
ADS .... Automatic Dependent Surveillance
ADSIM .... Airfield Delay Simulation Model
AERA .... Automated En Route Air Traffic Control
AEX .... Automated Execution
AF .... Airway Facilities
AFB .... Air Force Base
AGFS .... Aviation Gridded Forecast System
AGL .... Above Ground Level
AIP .... Airport Improvement Program
AIRNET .... Airport Network Simulation Model
AIV .... Aviation Impact Variable
ALP .... Airport Layout Plan
ALS .... Approach Lighting System
ALSF-II .... Approach Light System with Sequenced Flashers and CAT II modification
AMASS .... Airport Movement Area Safety System
AMSS .... Aeronautical Mobile Satellite Service
ANA .... Program Director for Automation, FAA
AND .... Associate Administrator for NAS Development, FAA
ANG .... Air National Guard
ANN .... Program Director for Navigation and Landing, FAA
ANR .... Program Director for Surveillance, FAA
ANS .... NAS Transition Implementation Service, FAA
ANW .... Program Director for Weather and Flight Service Stations, FAA
AOC .... Aeronautical Operational Control
AOR .... Operations Research Service, FAA
APO .... Office of Aviation Policy and Plans, FAA
APP .... Office of Airport Planning and Programming, FAA
ARD .... Research and Development Service, FAA
ARF .... Airport Reservation Function
ARINC .... Aeronautical Radio Incorporated
ARSA .... Airport Radar Surface Area
ARTCC .... Air Route Traffic Control Center
ARTS .... Automated Radar Terminal System
ASC .... Office of System Capacity and Requirements, FAA
ASCP .... Aviation System Capacity Plan
ASD .... Aircraft Situation Display
ASDE .... Airport Surface Detection Equipment
ASE .... NAS System Engineering Service, FAA
ASOS .... Automated Surface Observation System
ASP .... Arrival Sequencing Program
ASQP .... Airline Service Quality Performance
ASR .... Airport Surveillance Radar
ASTA .... Airport Surface Traffic Automation
ATC .... Air Traffic Control
ATCAA .... Air Traffic Control Assigned Airspace
ATCSCC .... Air Traffic Control System Command Center
ATIS .... Automated Terminal Information Service
ATN .... Aeronautical Telecommunications Network
ATMS .... Advanced Traffic Management System
ATO .... Air Traffic Operations Service, FAA
ATOMS .... Air Traffic Operations Management System
AWDL .... Aviation Weather Development Laboratory
AWOS .... Automated Weather Observing System
AWPG .... Aviation Weather Products Generator
CAA .... Civil Aviation Authority
CAEG .... Computer Aided Engineering Graphics
CARF .... Central Altitude Reservation Function

CASA .... Controller Automated Spacing Aid
CASTWG .... Converging Approach Standards Technical Working Group
CAT .... Category
CDTI .... Cockpit Display of Traffic Information
CFWSU .... Central Flow Weather Service Unit
CIP .... Capital Investment Plan
CNS .... Communication, Navigation, and Surveillance
CODAS .... Consolidated Operations and Delay Analysis System
CONDAT .... CONUS National Airspace Data Access Tool
CONUS .... Continental United States
CRDA .... Converging Runway Display Aid
CRS .... Computer Reservation System
CSD .... Critical Sector Detector
CTAS .... Center–TRACON Automation System
CTMA .... Center Traffic Management Advisor
CTR .... Civil Tilt Rotor
CVFP .... Charted Visual Flight Procedures
CW .... Continous Wave
CWSU .... Center Weather Service Unit
CY .... Calendar Year
DA .... Descent Advisor
DDAS .... Daily Decision Analysis System
DEMVAL .... Demonstration/Validation
DGPS .... Differential GPS
DH .... Decision Height
DLP .... Data Link Processor
DME .... Distance Measuring Equipment
DME/P .... Precision Distance Measuring Equipment
DOD .... Department of Defense
DOT .... Department of Transportation
DOTS .... Dynamic Ocean Tracking System
DSB .... Double Sideband
DSP .... Departure Sequencing Program
DSUA .... Dynamic Special-Use Airspace
DVOR .... Doppler VOR
ECVFP .... Expanded Charted Visual Flight Procedures
EDP .... Expedite Departure Path
EDPRT .... Expert Diagnostic, Predictive, and Resolution Tool
EFF .... Experimental Forecast Facility
EIS .... Environmental Impact Statement
EOF .... Emergency Operations Facility
ESP .... En Route Spacing Program
ETMS .... Enhanced Traffic Management System
EVAS .... Enhanced Vortex Advisory System
F&E .... Facilities and Equipment
FAA .... Federal Aviation Administration
FAATC .... Federal Aviation Administration Technical Center
FADE .... FAA-Airline Data Exchange
FAF .... Final Approach Fix
FANS .... Future Air Navigation System
FAST .... Final Approach Spacing Tool
FBO .... Fixed Base Operator
FDAD .... Full Digital ARTS Display
FL .... Flight Level
FLOWALTS ...... Flow Generation Function
FLOWSIM .... Traffic Flow Planning Simulation
FMA .... Final Monitor Aid
FMS .... Flight Management System
FSD .... Full-Scale Development
FSM .... Flight Simulation Monitor
FT .... Feet
FTMI .... Flight Operations and Air Traffic Management Integration
FY .... Fiscal Year
GA .... General Aviation
GAO .... General Accounting Office
GDP .... Gross Domestic Product
GLONASS .... Global Orbiting Navigational Satellite System
GNSS .... Global Navigation Satellite System
GPS .... Global Positioning System
GRADE .... Graphical Airspace Design Environment
HARS .... High Altitude Route System
HIRL .... High Intensity Runway Lights
HUD .... Heads-Up Display
HF .... High Frequency
ICAO .... International Civil Aviation Organization
IFCN .... Inter-Facility Flow Control Network
IFR .... Instrument Flight Rules
I-LAB .... Integration and Interaction Laboratory
ILS .... Instrument Landing System
IMC .... Instrument Meteorological Conditions

INMARSAT ...... International Maritime Satellite
IOC .... Initial Operational Capability
ISSS .... Initial Sector Suite System
ITS .... Intelligent Tutoring System
ITWS .... Integrated Terminal Weather System
LDA .... Localizer Directional Aid
LIP .... Limited Implementation Program
LLWAS .... Low Level Wind Shear Alert System
LORAN .... Long Range Navigation
MA .... Monitor Alert
MALSR .... Medium Intensity Approach Lighting System with RAIL
MAP .... Military Airport Program
MAP .... Missed Approach Point
MASPS .... Minimum Aviation System Performance Standards
MCAS .... Marine Corps Air Station
MCF .... Metroplex Control Facility
MDCRS .... Meteorological Data Collection and Reporting System
MIT .... Miles In Trail
MLS .... Microwave Landing System
MNPS .... Minimum Navigation Performance Specifications
MOA .... Military Operations Area
MOPS .... Minimum Operations Performance Standards
MRAD .... Milli-Radian
MWP .... Meteorologist Weather Processor
NAS .... Naval Air Station
NAS .... National Airspace System
NASP .... NAS Plan
NASPAC .... NAS Performance Analysis Capability
NASPALS .... NAS Precision Approach and Landing System
NASSIM .... NAS Simulation Model
NATSPG .... North Atlantic Special Planning Group
NAVAID .... Navigational Aid
NCF .... National Control Facility
NCP .... NAS Change Proposal
NEXRAD .... Next Generation Weather Radar
NFDC .... National Flight Data Center
NMC .... National Meteorological Center
NMCC .... National Maintenance Coordination Complex
NM .... Nautical Mile
NOAA .... National Oceanic and Atmospheric Administration
NPIAS .... National Plan of Integrated Airport Systems
NSC .... National Simulation Capability
NTP .... National Transportation Policy
NTZ .... No Transgression Zone
NWS .... National Weather Service
OAG .... *Official Airline Guide*
ODALS .... Omni-Directional Approach Lighting System
ODAPS .... Oceanic Display and Planning System
ODF .... Oceanic Development Facility
ODL .... Oceanic Data Link
OMB .... Office of Management and Budget
OPTIFLOW ..... Optimized Flow Planning
ORD .... Operational Readiness Date
ORD .... Operational Readiness Demonstration
OST .... Office of the Secretary of Transportation
OTFP .... Operational Traffic Flow Planning
OTPS .... Oceanic Traffic Planning System
PADS .... Planned Arrival and Departure System
PAPI .... Precision Approach Path Indicator
PCA .... Positive Control Airspace
PDC .... Pre-Departure Clearance
PRM .... Precision Runway Monitor
R&D .... Research and Development
RE&D .... Research, Engineering, and Development
RAIL .... Runway Alignment Indicator Lights
RDSIM .... Runway Delay Simulation Model
REIL .... Runway End Identifier Lights
RFP .... Request for Proposal
RGCSP .... Review of General Concepts of Separation Panel
RMM .... Remote Maintenance Monitoring
RMP .... Rotorcraft Master Plan
RNAV .... Remote Area Navigation
RNP .... Required Navigation Performance
RNPC .... Required Navigation Performance Capability
ROT .... Runway Occupancy Time
RSLS .... Runway Status Light System
RTCA .... Radio Technical Commission for Aeronautics

RVR .... Runway Visual Range

SAR .... System Analysis Recording

SARPS .... Standards and Recommended Practices

SATCOM .... Satellite Communications

SCIA .... Simultaneous Converging Instrument Approaches

SDAT .... Sector Design Analysis Tool

SDRS .... Standardized Delay Reporting System

SE .... Strategy Evaluation

SID .... Standard Instrument Departure

SIMMOD .... Airport and Airspace Simulation Model

SM .... Statute Mile

SMARTFLOW .. Knowledge-Based Flow Planning

SMGC .... Surface Movement Guidance and Control

SMS .... Simulation Modeling System

SOIR .... Simultaneous Operations on Intersecting Runways

SOIWR .... Simultaneous Operations on Intersecting Wet Runways

STAR .... Standard Terminal Arrival Route

SUA .... Special Use Airspace

TACAN .... Tactical Air Navigation — UHF omnidirectional course and distance information

TASS .... Terminal Area Surveillance System

TATCA .... Terminal ATC Automation

TAVT .... Terminal Airspace Visualization Tool

TCA .... Terminal Control Area

TCAS .... Traffic Alert and Collision Avoidance System

TCCC .... Tower Control Computer Complex

TDP .... Technical Data Package

TERPS .... Terminal Instrument Procedures

TFM .... Traffic Flow Management

TIDS .... Tower Integrated Display System

TMA .... Traffic Management Advisor

TMCC .... Traffic Management Computer Complex

TMS .... Traffic Management System

TMU .... Traffic Management Unit

TRACON .... Terminal Radar Approach Control

TSC .... Volpe Transportation Systems Center

TSO .... Technical Standard Order

TTMA .... TRACON Traffic Management Advisor

TVOR .... Terminal VOR

TWDR .... Terminal Weather Doppler Radar

USWRP .... U.S. Weather Research Program

VASI .... Visual Approach Slope Indicators

VF .... Vertical Flight

VFR .... Visual Flight Rules

VHF .... Very High Frequency

VMC .... Visual Meteorological Conditions

VOR .... VHF Omnidirectional Range — course information only

VORTAC .... Combined VOR and TACAN Navigational Facility

VOT .... VOR Test

WAAS .... Wide Area Augmentation System

Appendix J

Index*

A

B

* A note concerning airport names and locations:

This index does not reference the occurrences of airports that appear in any Tables or Figures. For a listing of Tables and Figures, please see the Table of Contents. For a listing of airport layouts and their locations, please refer to Appendix B.

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